Disaster Management

A Reader

Editors

S. Rajagopal

Sridhar K. Chari

NATIONAL INSTITUTE OF ADVANCED STUDIES

Bangalore, India

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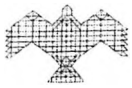

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Preface

The following is a collection of papers presented by eminent experts during the annual course on disaster management conducted over the last few years by the National Institute of Advanced Studies, Bangalore, for senior IAS officers from across the country.

We place this selection before the general reader, administrators, politicians, academics and future participants of the NIAS course, in the hope that it will be found useful and interesting. We believe that the collective experience of the contributors can serve to generate new insights and methodologies in tackling disasters in the country. A key lesson is while it is easy to glibly blame our large population, it is administrative, regulatory and policy gaps which need to be addressed urgently.

We would like to acknowledge the invaluable assistance of Ms Gayathri Lokhande both in conducting the courses and in preparing this volume.

S Rajagopal
Sridhar K Chari
Course-Coordinators

R N IYENGAR

Earthquakes in India – An Engineering Perspective

1. Introduction

Earthquakes are rare events, rarer than floods and hurricanes but the impressions left on the community even by a small tremor are long-lasting. While floods and droughts may extend over weeks or even a season, earthquakes occur for a few seconds only. Advances in meteorology have made it possible to issue a warning about hurricanes. However, precise prediction of earthquake occurrence has not been so far possible. While broad regions prone to earthquakes can be identified, the time and place of the next earthquake remains completely uncertain. In this sense an earthquake can be appropriately called a shock. Earthquakes are associated with crustal adjustments due to tectonic forces. The epicentres of major earthquakes lie in the proximity of geological faults. There are three major seismic zones in the world. One of these passes through India along the Himalayas. The majority of earthquakes in India have occurred in and around this zone only. However, earthquakes occur at other places also as seen in the epicentral map of India (Fig. 1).

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Roughly, it may be stated that the southern region is less prone to shocks than the northern region. This does not mean in any way that strong earthquakes are ruled out in the South.

2. Seismicity of India

In order to understand the seismicity of India, the country is generally divided into six regions:

i) Kashmir and Western Himalayas

ii) Nepal Himalayas

iii) (a) Assam (N-E India)

(b) Andaman – Nicobar islands

iv) Gangetic basin and Rajasthan

v) Cambay and the Rann of Cutch

vi) Peninsular India.

The number of earthquakes of magnitude $M \geq 5$ recorded in the recent past in each of the six zones is as follows.

Zone	No. of earthquakes	Period
i	32	1828-1968
ii	96	1803-1970
iii(a)	313	1822-1971
iii(b)	146	1917-1971
iv	18	1720-1970
v	10	1819-1965
vi	41	1764-2000

3. Earthquakes in South India

In Peninsular India, i.e. south of 28° N latitude, about 380 earthquakes have been reliably experienced in a period of 600 years. For the four southern states taken together there have been some 152 earthquakes in the last 600 years. Bangalore itself has been identified as the epicentre for two earthquakes. Bangalore or its surroundings have been identified as epicentres for three earthquakes which occurred on 13.5.1824; 7.1.1916 and 29.1.2001. A stone inscription in Kannada at Billanakote of Nelamangala Taluk records that the earth shook four times on Kali 4608, Prabhava Samvat Shravana Shuddha Shasti, Thursday. This corresponds to 15th July 1507 AD. Some of the significant earthquakes in Peninsular India are presented in Table 1. The estimated maximum intensity (MMI) and the magnitude are also given in this table. The interest of an engineer in earthquakes is mainly from the design and construction point of view. He studies them so that the structures he builds can safely withstand the sudden earthquake shocks and the associated erratic ground motion. Earthquake engineering is essentially the analysis, design and construction of structures to respond to this ground motion with minimum or no damage. To this we may add related topics such as damage estimation, repair, strengthening and retrofitting of existing structures. Before studying the seismic behaviour of structures, it is necessary to know the causes and characteristics of earthquakes. It is also essential to know how ground motion is measured and specified in engineering problems.

Table 1 Earthquakes of Peninsular India in the 20th century

No.	Name	Date	Epicenter °N - °E	Focal Depth (km)	Mag. (M_L)	Epicentral Intensity (I_o)
1	Coimbatore	7.2.1900	10.8 - 76.8	-	6.0	VIII
2	Vijayanagaram	17.4.1917	18.0 – 84.0	-	5.5	VII
3	Anjar	21.7.1956	23.0 – 70.0	-	7.0	IX
4	Ongole	13.10.1959	15.6 – 80.1	-	5.0	VII

5	Ongole	23.3.1967	15.6 – 80.0	-	5.8	VII
6	Koyna	13.9.1967	17.4 – 73.7	-	5.8	VII
7	Koyna	10.12.1967	17.5 – 73.7	10	6.3	VIII
8	Bhadrachalam	13.4.1969	17.9 – 80.6	10	5.3	VII
9	Broach	23.3.1970	21.7 – 72.9	15	6.0	VII
10	Coimbatore	29.7.1972	11.0 – 77.0	-	5.0	VI
11	Shimoga	2.5.1975	13.8 – 75.3	-	5.0	V
12	Krishnagiri	20.3.1984	12.58-77.8	6	4.5	VI
13	Idukki	7.6.1988	9.81-77.21	5	4.5	V
14	Khillari	29.9.1993	18.06 – 77.5	7	6.2	VIII
15	Jabalpur	21.5.1997	23.0 – 80.0	30	6.0	VIII
16	Bhuj, Kutch	26.1.2001	23.4 – 70.28	24	7	XI

4. Causes of Earthquakes

Earthquakes can be caused by volcanic activity, underground explosions, collpase of caves or slipping of geological faults. The most important cause from an engineering point of view, it is believed at present, is the movement of faults, which are buried deep below the earth's surface (Fig.2). For example, for the Khillari event the focal depth was 5 km. For the Bhuj earthquake this is estimated to be 24 km.

5. Focus, Epicentre, Magnitude, Intensity

The Focus is the point in the crust of the earth from where the seismic waves start. Focus is also called Centre, Hypofocus or Hypocentre. The Epicentre is the vertical projection of the focus on the surface of the earth. If sufficient instrumental data are not available to locate the epicentre precisely, the distribution of the damage is observed carefully and the point of most intense shaking is taken as the epicentre. A strong earthquake is associated with a slip over a wide fault region with enormous release of strain energy in the form of seismic waves. C.F. Richter in trying

to give a measure to the size of earthquakes defined the magnitude as

$$M = \text{Log}_{10} (A/A_0)$$

where A is the maximum amplitude recorded by a Wood-Anderson seismograph at a distance of 100 km from the centre of the disturbance and A_0 is an amplitude of one thousandth of a millimeter. In practice, however, the amplitude has to be extrapolated since measurements cannot be done at exactly 100 km from the epicentre. Generally, an average magnitude M is determined from a number of recordings. The magnitude can be related to the energy release during an earthquake. A popular empirical relationship is

$$\text{Log}_{10} E = 11.8 + 1.5 M$$

where E is the energy released in ergs. Roughly speaking, earthquakes of magnitude equal to or greater than 5.0 are potentially dangerous to structures. Below magnitude 5.0 the duration of ground motion would be short and acceleration levels small which generally do not produce damage in civil engineering structures. In terms of energy released, nuclear explosions compare with earthquakes. For example, a 50 Megaton explosion produces the same energy as released by a 7.3 magnitude earthquake (Table 2).

Table 2: Analogy between Magnitude and TNT explosion

M_L	Weight of TNT
1	171 g
2	6 kg
3	180 kg
4	5 t
5	181 t
6	5700 t
7	1,80909 t
8	5,700,00 t
9	180,909,091 t

The magnitude M refers to the strength of the earthquake source, whereas the intensity I refers to the effect of the earthquake on structures and human beings. A standard way of doing this is by giving a number on the Modified Mercalli Intensity (MMI) scale to a region or city affected by the given earthquake. This is not a very precise measure since the estimate made is largely subjective. However, this descriptor has remained popular for the simple fashion in which the spatial pattern of damage is depicted. The MMI scale is described in Table 3. Alternate intensity descriptions such as the European MSK scale and Japanese scales are also in vogue.

Table 3. Modified Mercalli Intensity Scale (Abridged)

Intensity	Severity
I	Not felt except by a very few under specially favourable circmstances
II	Felt only by a few persons at rest, especially on upper floors of buildings; delicately suspended objects may swing
III	Felt quite noticeably indoors, specially on upper floors of buildings, but many people do not recognize it as an earthquake; standing motor cars may rock slightly; vibration may be felt like the passing of a truck.
IV	During the day, felt indoors by many, outdoors by a few; at night some awakened; dishes, windows, doors disturbed; walls make creaking sound; sensation like heavy truck striking the building; standing motor cars rock noticeably.
V	Felt by nearly everyone; many awakened; some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned; disturbance of trees, poles, and other objects noticed sometimes; pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; damage slight.

VII	Everybody runs outdoors, damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly-built or badly-designed structures; some chimneys broken; noticed by persons driving motor cars.
VIII	Damage slight in specially-designed structures; considerable in ordinary but substantial buildings with partial collapse; very heavy in poorly-built structures; panel walls thrown out of framed structures; falling of chimneys, factor stacks, columns, monuments, walls; heavy furniture overturned; sand and mud ejected in small amounts; changes in well water; persons driving motor cars disturbed.
IX	Damage considerable in specially-designed structures; well-designed framed structures thrown out of plumb; very heavy in substantial buildings with partial collapse; buildings shifted off foundations; ground cracked conspicuously; underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and framed structures with foundations destroyed; ground badly cracked; rails bent; landslides considerable from river banks and steep slopes; shifted sand and mud; water splashed over banks.
XI	Few, if any, masonry structures remain standing; bridges destroyed; broad fissures in ground, underground pipelines completely out of service; earth slumps and landslips in soft ground; rails bent greatly.
XII	Total damage, waves seen on ground surfaces; lines of sight and level destroyed; objects thrown upward into the air.

6. Strong Motion Earthquakes

Damage to man-made structures during an earthquake depends directly on the way the ground vibrates below the structure. The fundamental data on strong earthquakes are in the form of ground acceleration, velocity, and displacement records obtained near the causative fault. The most striking feature of these is their random nature. In Fig. 3, the strong motion records of the Koyna - 1967 earthquake are shown. Generally the ground acceleration increases from a very low value to a high maximum and gradually decreases. The characteristics of ground motion depend on the magnitude, epicentral distance, site conditions etc. Generally, higher accelerations are associated with larger magnitudes and shorter epicentral distances. The frequency content, a measure of which is the rate of zero crossings of the accelerogram, is also affected by these quantities. Far away from the epicentre, high frequency components get attenuated. Also, high frequencies will be present more on hard rock sites than on soft soil. Ground motion at a site may be broadly classified into four groups:

i) Single shock

These occur at short distances from the epicentre, only on firm ground, and only for shallow focus. The Port Hueneme, USA (1987), Agadir, Morocco (1960) and Skopje, Yugoslavia (1963), earthquakes are considered to be typical examples of this type of ground motion.

ii) Long irregular motion

The El Centro (1940), the Koyna (1967) records exemplify this kind of motion. These are highly erratic and can be described only as random processes. They are recorded on firm ground at moderate epicentral distances. Uttarakashi (1991) and Chamoli (1999) records also belong to this class.

iii) Very long dominantly periodic motion

This type of motion is recorded on layered soft soil. Mexican earthquakes are typical examples. Motion at Ahmedabad during the Bhuj earthquake is another example.

iv) Large-scale permanent ground deformations

Near to the epicentre, there is possibility of soil liquefaction, large-scale ground cracking and deformation. These effects were seen during the Nigata, Anchorage and Bhuj earthquakes. In practice, ground motion characteristics may look different at different sites for the same event. This happens due to the inhomogeneity and anisotropy of the medium, layering of the soil deposits and topography of the site. Engineering solutions in terms of earthquake-resistant design of structures is possible for ground vibration. Unfortunately, proven technological solutions to handle large-scale permanent ground movements near the faults are not available at present.

7. Planning for Seismic Risk Mitigation

The recent spate of earthquakes in the country has highlighted the importance of having a well-planned reduction strategy built into the larger policy framework of sustainable development. The vulnerability of India's urban areas was dramatically demonstrated by the Kutch earthquake of 26 January 2001, which did not have the more frequent Himalayan origin. The looming seismic risk to cities such as Guwahati, Shillong, Dehradun, Delhi and others can be perceived against the backdrop of earthquakes originating in the Himalayan region and in the Indo-Gangetic plains. Time and again earthquakes have occurred without warning. As population increases and our cities expand, the potential for earthquake loss increases. It has to be remembered that the principal cause of death and damage is from collapse of buildings, and failure of important infrastructure, the possibility of which

even otherwise increases with time. While the financial loss in absolute terms is a function of the state of development, initial investment and cost of living indices, the vulnerability to natural disasters is dependent on the social and economic condition of the population. It is estimated that loss to GNP can be twenty times greater in developing countries than in developed countries. Thus, it is prudent to plan, develop and protect built environment from possible future destruction. In this context microzonation plays a key role in planning and protecting the built environment in the earthquake-prone cities of India.

8. Microzonation

The present seismic zonation map of IS:1893-1984 divides the country into five zones, I to V associated with damage risk of MMI = V (or less), VI, VII, VIII and IX (and above). However, the revision of 2002 leaves out zone I, as this region has been revised upwards to zone II. This is supposedly based on statistical analysis of past data. In any case, frequency of occurrence of earthquakes is not reflected in the IS map. Further, in this approach, large regions are clubbed together with no rational method for reflecting issues like improvements in construction techniques or aging of buildings which may alter the damage scenario. The short length of historical data used in the preparation of the map has led to serious errors as is well known, after the occurrence of the Khillari and Jabalpur earthquakes. The engineering codes are expected to help builders quantify the seismic hazard and consequent forces. These are to be followed by recommended methods of structural design. In a vast country like ours where the seismic hazard is not well investigated, dividing the country into four zones is an approximate and crude exercise. Microzonation, on the other hand, is an exercise carried out on the scale of a city block or say on an area of the order of 1 sq. km. Thus, finer aspects such as properties of soil deposits, age of buildings and construction details can be included in microzonation studies. Microzonation can be carried out on any one parameter or combinations of parameters on smaller spatial scales. Thus, one may stop this exercise at the seismic hazard estimation level or carry it further to vulnerability analysis of

buildings to finally arrive at damage and loss estimation in Rupee terms. Even in this exercise, several variations are possible depending on the sophistication with which one likes to handle the uncertainties associated with seismic hazard and consequent damage scenario. The city of Tokyo has been micro-zoned on a refined basis (Fig. 4).

9. Seismic Hazard

The actual ground shaking at any location during an earthquake depends on three major parameters, namely, the source, path and site. However, in hazard analysis due to uncertainty of future occurrence of shocks, considerable past data, modelling and extrapolation will be necessary. Probabilistic hazard analysis is the most rational approach for describing the seismic scenario. This again may be split into three heads, namely, source identification, recurrence relations and attenuation laws. Earthquake sources identified by seismologists are to be modelled as point, line or area sources. Places of high seismicity may have to be modelled in terms of line and area sources only. In regions where no identifiable fault is known, only point sources have to be assumed. The seismicity of the source is determined from past data. Generally, the Gutenberg-Richter relationship for recurrence Log10 N(m) = a-bm, where N(m) is the number of events of magnitude greater than m, is assumed to be valid. The constants, a and b are specific to the source and are found from the available database. The occurrence of an earthquake from the postulated source is modelled as a homogeneous Poisson process. More complex models such as non-homogeneous Poisson processes, Bayesian models and semi-Markov processes have also been proposed in the literature. An attenuation relationship is chosen to express the decay of the Peak Ground Acceleration (PGA) with distance from source. The seismic hazard of the site is the probability of the PGA exceeding a given value in a time interval. This is obtained by including the effects from all potential sources. Let the hazard from the i-th source be $p_i(a_p, T) = \text{Prob}(\hat{x}(t) \geq a_p$ at least once in T years. If there are 'n' number of sources

contributing to the hazard, assuming statistical independence, one gets the final hazard as : $P(a_p, T) = 1 - \prod_{i=1}^{n}\left[1 - p_i(a_p, T)\right]$.

10. Site Effects

Viewed from the point of safety of critical structures, accurate knowledge of the geology of the site along with geophysical data is very essential. Evidence is available from all over the world that damage is more on soft soil than on hard rock. Some other well-known facts are as follows:

i) Surface faulting can rupture almost any facility to make it unserviceable. In the 21 September 1999 Chi-Chi, Taiwan earthquake the Chelangpu fault ruptured a bridge and broke the Shih Kang dam. In the 17 August 1999 Turkey earthquake, the northern Anatolia fault movement was responsible for knocking the Goluck naval base out of action due to surface rupture. A military building collapsed killing several high-ranking commanders.

ii) Large settlements and differential movements can be attributed to compaction of loose granular soils. Example: Back fills of bridges during the 1964 Nigata, Japan earthquake, and 2001 Bhuj earthquake.

iii) Settlement and tilting in buildings on saturated loose sandy soils which can liquefy. Example : Bihar earthquake of 1934, Nigata earthquake of 1964, Bhuj earthquake effects at Bachau and Kandla Port.

iv) Lateral movements on natural slopes. Example: Uttarakashi earthquake of 1991, Anchorage earthquake in Alaska, 1964.

v) Settlement of man-made embankments. Upper San Fernando dam suffered differential movement and settlement of crest by about 1 m after the 1971 San

Francisco earthquake. Makni dam had longitudinal cracks after the Khillari earthquake of 1993. In the Gujarath earthquake several dams like Chang, Rudramata, Taper, Fategadh, Bukhi were extensively damaged.

One of the classic examples of building damage due to local soil conditions is from the Caracas earthquake of 1967. A detailed study of this earthquake has led to the results shown in Fig. 5. For 3-5 storey buildings, maximum damage was observed when they were on soil layers 30-50 m deep. For tall buildings over 10 storeys high, damage was high on deposits deeper than 160 m. It is clear that these damages are functions of the intensity of ground shaking. Thus, evaluation of risk for a particular building or structure must incorporate estimation of ground vibration that is most likely to be induced at that specific site. There have been several cases of damage due to soil amplification (local soil layer characteristics) in Indian earthquakes. In the Khillari earthquake, 100 km away from the epicentre, damage intensity increased along the Bhima river bank causing destruction at villages Bhosga(k) and Umrani. During the Uttarakashi (1991) and Chamoli (1999) earthquakes, certain small pockets in Delhi experienced damage. It is well known how in the recent Bhuj earthquake more than 200 km away from the epicentre, a belt in Ahmedabad experienced collapse of multistorey buildings.

11. Vulnerability Analysis

Damage prognosis and economic loss estimation in Rupee terms may be described as vulnerability analysis. This may be carried out in three or more steps such as:

i. Inventory creation of buildings and related infrastructure.

ii. Relationship between the category of structure and its possible damage due to the hazard.

iii. Loss computation.

A building classification scheme is an essential ingredient of this exercise. There can be no universal or unique approach for classification of buildings. Even within a country, grouping may differ depending on the region under consideration. In the USA, for loss estimation, the building classification developed by Algermissen and Steinbrugge has 21 categories. ATC (Applied Technology Council) has classified infrastructure facilities into 78 classes, 40 of which are buildings. The latter is based more on the Californian practice. It is clear that at every stage some trade-off or compromise is necessary. Too detailed a classification with a large number of structural classes will be cumbersome for data management. On the other hand, if the scheme is too coarse the results would be inaccurate. For Indian conditions, classification of buildings for purposes of damage prognosis is not available at present. The National Building Code (NBC 1984) has proposed nine functional classes of buildings, namely:

A : Residential	B: Educational	C: Institutional
D: Assembly	E : Business	F : Mercantile
G : Industrial	H : Storage	J : Hazardous

To this we should add one more class, namely, K : Heritage/ Monumental.

12. Hazard-Damage Relationship

Seismic hazard leads to ground vibration, soil liquefaction, landslides, subsidence and differential ground movement. Building damage will be mainly due to one or more of these primary effects. Effects such as fire and explosion are thought to be secondary in forecasting building damage and subsequent loss. Among the primary hazards, ground shaking is the most important. Thus, after the building classification, motion-damage relationships are to be established for the region under study. A popular indicator of damage is the damage ratio, which is the ratio of number of buildings damaged to the total number of buildings in the region. Another indicator is the damage factor (DF) which is the ratio of the monetary loss to the replacement value of the building. DPM represents the DF for different ground motion levels described in terms of MMI or PGA values. The

damage to a building for a given ground motion intensity is divided into several damage states. Each state represents a range of damage factors. The elements in the matrix represent the probability of occurrence of a particular damage state under a given intensity of motion. Ideally DPM is to be found from actual damage data during earthquakes. This of course will not be available in all places for all types of earthquakes. Thus, expert opinion and judgement are used to formulate DPM. For Indian conditions, a sample DPM for rural stone masonry is shown in Table 3. Efforts are needed to formulate suitable DPM for Indian construction practices and vulnerability scenario.

13. Loss Estimation

When the total loss for a large region like a city has to be found, it will be convenient to consider small units such as blocks. In each block the average loss for structural class j is obtained as:

$$E_j(T) = \sum_{i=0}^{r} L_{ij}\left[P(I_j, T - P(I_{i+1}, T)\right],$$

where $P(I_i,T)$ = Probability of having at least one occurrence of intensity equal to or greater than I_i in a time period of T years;

L_{ij} = Mean damage factor for intensity I_i for structural class j.

Here I_0 and I_r refer to the events of least and maximum intensity possible. For the structural class j, the total replacement value is given by :

$$R_j = \sum_{k=0}^{n} a_{kj} r_{kj}$$

where a_{kj} = Total area of buildings belonging to social function class k, and engineering class j;

r_{kj} = Replacement value per unit area;

Table 3a. Damage Probability Matrix (DPM) for Rural Stone Masonry (Khillari earthquake)

I* DG**	VI (N=460)	VII (N=295)	VII (N=397)
0	0.006	0.003	--
1	0.067	0.01	--
2	0.093	0.03	0.02
3	0.027	0.132	0.262
4	0.748	0.754	0.451
5	0.059	0.081	0.267

Table 3b. DPM for rural stone masonry (Chamoli earthquake)

I* DG**	VII (N=989)	VIII (N=705)
0	0.166	0.085
1	0.219	0.038
2	0.0394	0.139
3	0.075	0.16
4	0.121	0.46
5	0.025	0.172

I* = Intensity DG** = Damage Grade

n = Number of social function classes.

Here it is to be noted that depending on the social function such as residential, industrial, commercial, governmental, cultural, religious, education, health, etc., the replacement value for the same structural class may vary. The total monetary damage for the block k in T years is given by :

$$D_k(T) = \sum_{j=o}^{m} E_j(T)R_j$$

where m is the total number of structural classes considered.

14. Conclusion

It is recognized by seismologists and engineers alike, that no part of India can be considered to be free of seismic hazard. In this connection, vulnerability of our cities, such as Ahmedabad, Guwahati, Mumbai, Delhi, Pune, Coimbatore, Bellary, to name only a few, should be a cause for concern. Enforcement of Building Codes by Municipal authorities would definitely help in reducing future earthquake-related damage to buildings in our cities. However this should not be presumed to be the last word in professional Civil Engineering practice. It would be prudent to plan in advance, retrofitting and strengthening of vulnerable building stock and other infrastructure such as bridges, dams, hospitals, and power plants all over India. Also, future town planning and habitat development policies should not overlook the spatial variation of seismic risk dependent on surface faulting, liquefaction potential and sub-surface soil conditions. Microzonation is a rational approach for dealing with the above issues in a systematic fashion. It is the best technological guide available to the planners of built environment in the vulnerable regions of the country. Engineers, administrators and policy planners are urged to encourage and in fact, actively undertake rational seismic hazard estimation of urban areas of India at an early date.

Appendix A

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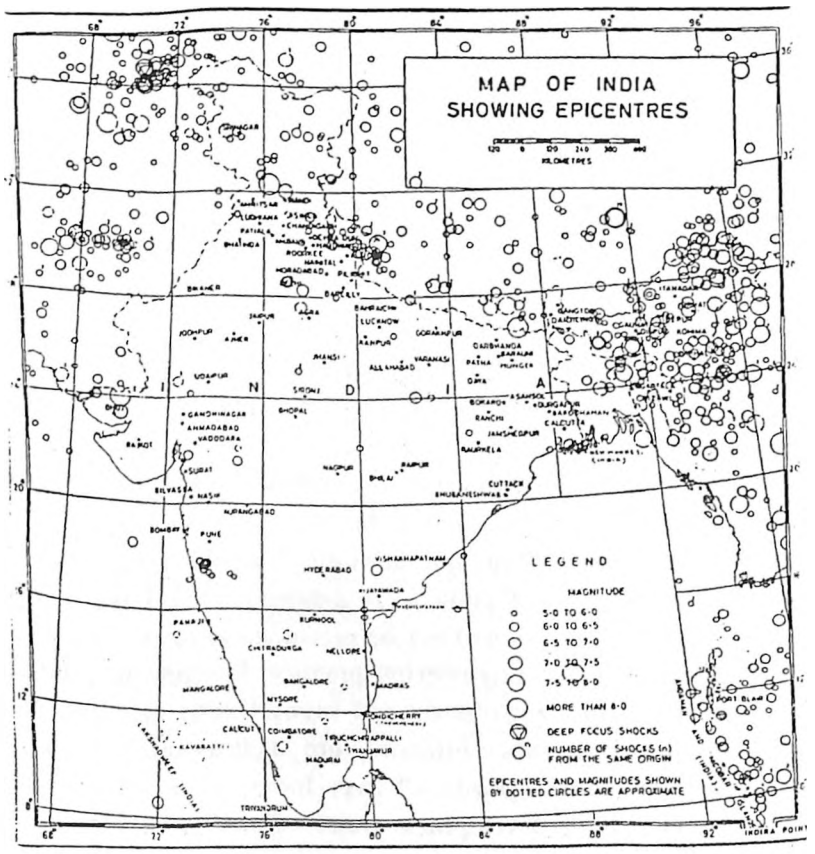


The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Responsibility for the correctness of internal details shown on the maps rests with the publishers.

Based upon Survey of India map with the permission of the Surveyor General of India.

Fig. 1. Epicentral Map of India

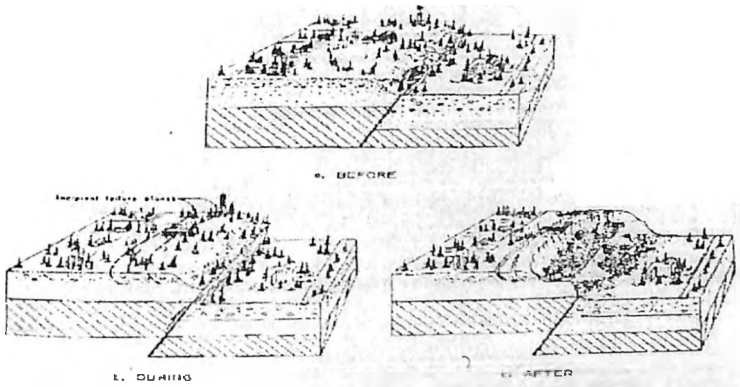
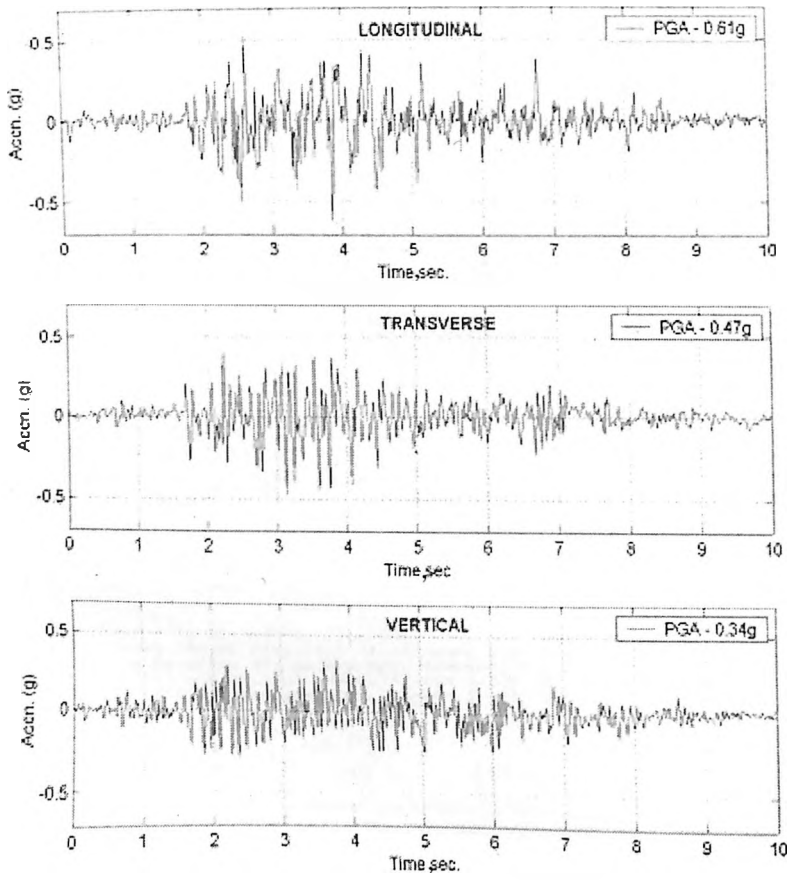


Figure 2 Damage from thrust (reverse) fault; earth displacements induced on the upthrown block at a distance from the fault trace (after Cluff, Slemmons, and Waggoner, 1970).



Strong Motion Accelerograph Records of Koyna 11.12.1967 Earthquake as Recorded at the Base of the Koyna Dam

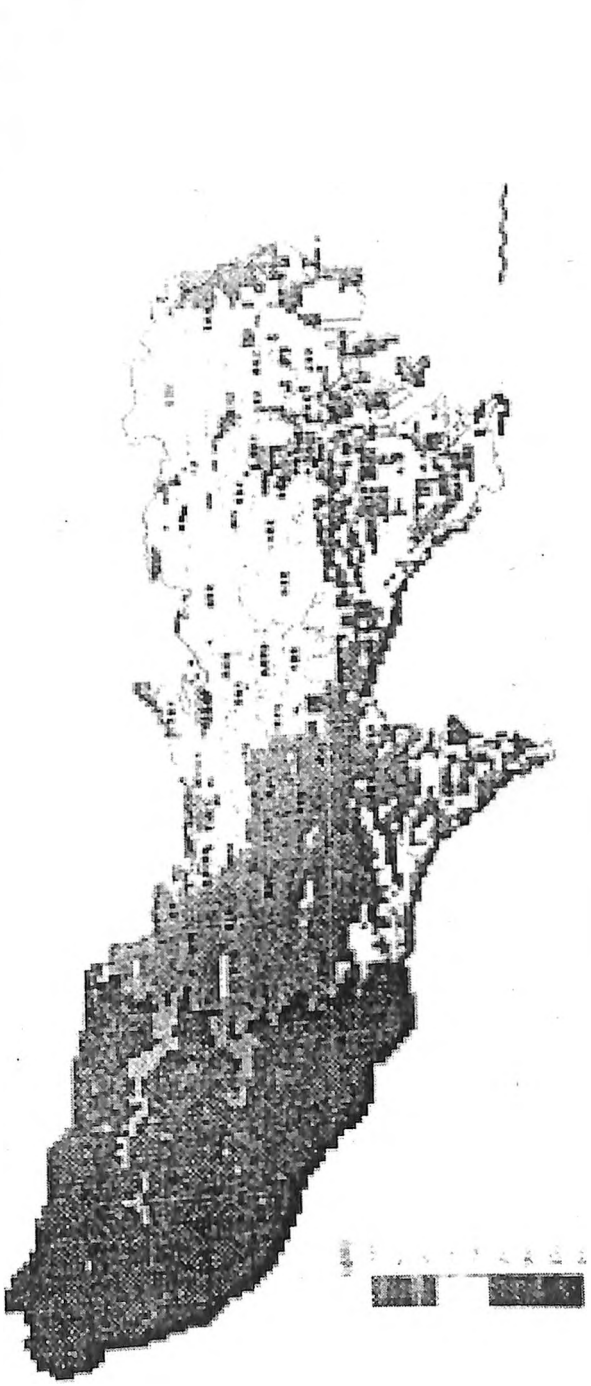


Fig. 26 Distribution of Ground Surface Acceleration

Fig. 27 Results of Liquefaction Assessment

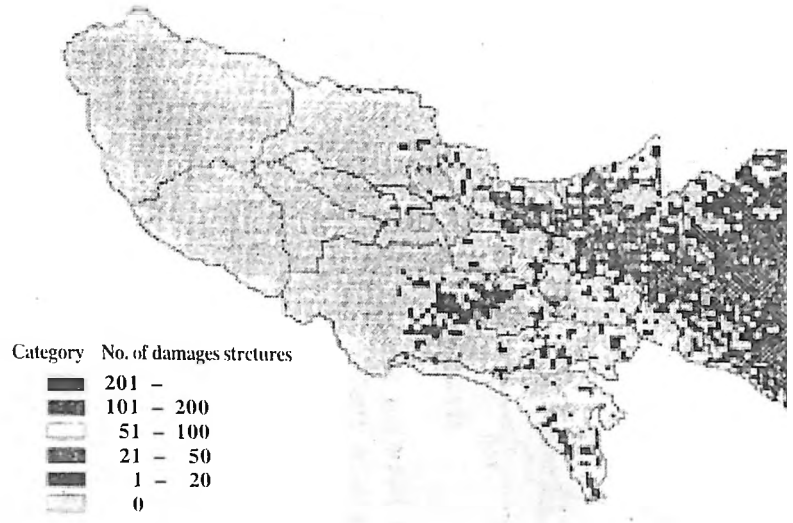
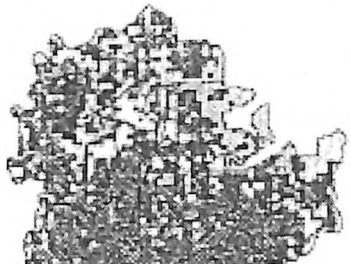


Fig. 4 Numbers Structures Damaged by Tremors and Liquefaction



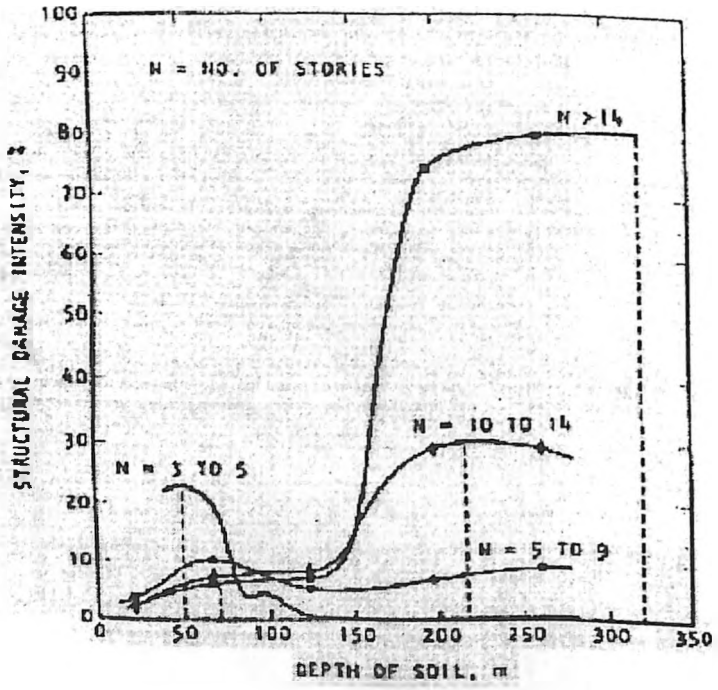
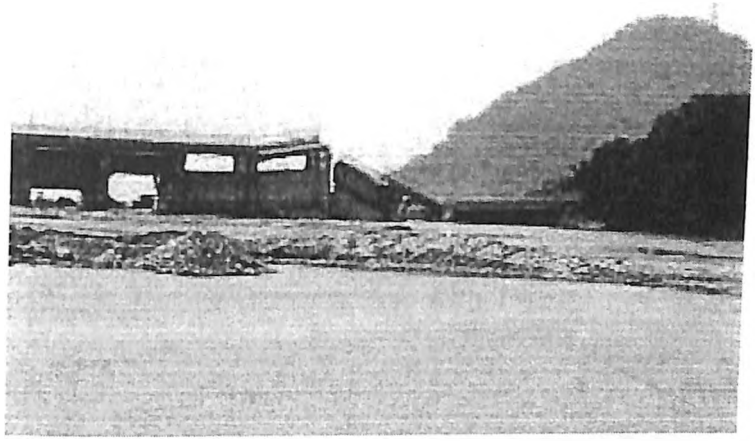


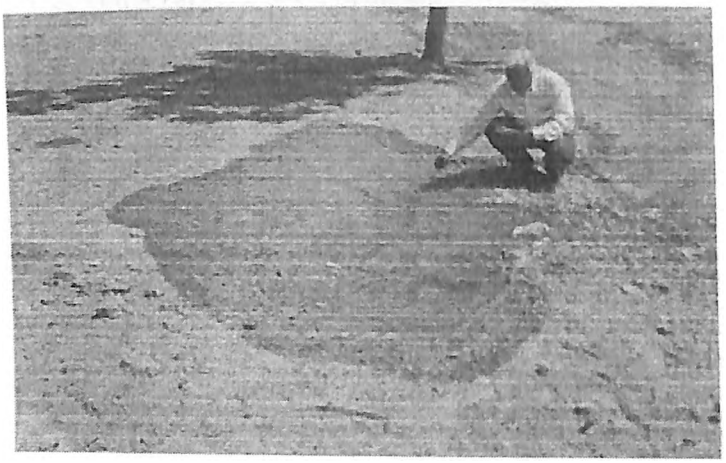
Fig. 5 Relationship Between Structural Damage Intensity and Soil Depth in 1967 Caracas Earthquake (From Seed et. al.)

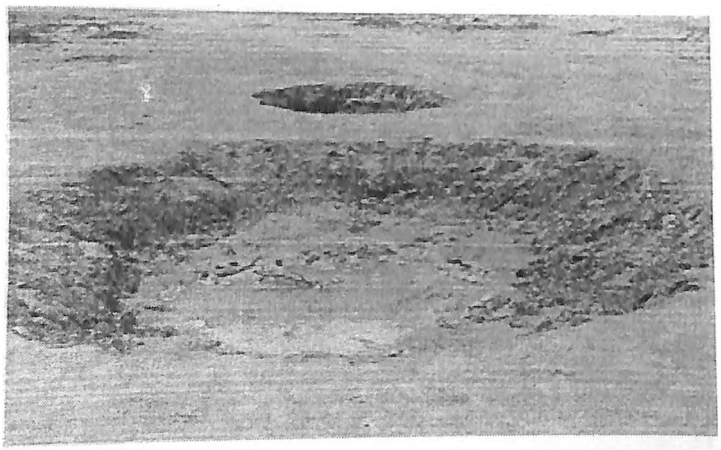


Relative uplift of approximately 9.3 m through right abutment of Shihkang Dam; vertical offset measured from top of dam south of fault to top of dam north of fault (N 24.2832 E120.7695; 9/30/99).

View to west of Shihkang Dam damage at right abutment (N 24.2832 E 120.7695;9/30/99)

Chi-Chi Earthquake, Taiwan





Liquefaction during Bhuj Earthquake (26th Jan 2001)

Ground Rupture in Epicentral Tract (Bhuj Earthquake)

MAJOR EARTHQUAKES OF INDIA

Date	Place	M or I0	Remarks
July 10, 1505	Agra	X	Devastating
Sept 1555	Srinagar	XII	600 deaths
July 15, 1720	Delhi	IX	Widespread damage
Sept 1, 1803	Mathura	6.5	Qutub Minar affected
Oct 5, 1803	Kumaon	6.5	300 Deaths
June 16, 1819	Kutch	8.0	3 Towns Destroyed
June 6, 1828	Srinagar	6.0	100 Deaths
Jan 10, 1869	Assam	7.5	Widespread damage
May 30, 1885	Srinagar	7.0	Widespread damage
June 12, 1897	Shillong	8.7	Widespread damage
April 4, 1907	Kangra, HP	8.0	1000 deaths
Feb 28, 1906	HP	7.0	Heavy damage
Aug 28, 1916	Nepal	7.5	Widespread damage
July 8, 1918	Assam	7.8	Heavy damage
July 2, 1930	Assam	7.1	Damage to Dhubri
Jan 15, 1934	Bihar, Nepal	8.25	Large number of deaths
June 23, 1941	Andamans	8.1	Heavy damage
July 29, 1947	Dibrugarh	7.75	Heavy damage
Aug 15, 1950	Assam	8.0	Heavy damage
Nov 18, 1951	Assam	8.0	Heavy damage
Dec 10, 1967	Maharashtra	6.1	Koyna Nagar razed
April 13, 1969	Bhadrachalam	6.5	Heavy damage
April 28, 1986	Dharamashala, HP	5.7	Heavy damage
Jan 21, 1988	Bihar	6.5	Large number of deaths
Oct 20, 1991	Uttarakashi	6.6	Deaths
Sept 30, 1993	Khillari	6.4	7000 deaths
May 22, 1997	Jabalpur	5.8	Widespread damage
Mar 29, 1999	Chamoli	6.5	
Jan 26, 2001	Gujarat	7	20,000 deaths

A K BHATNAGAR

Floods and Cyclones – Meteorological and Climatological Aspects, and Early Warning System

Abstract

About eighty per cent of the area of the Indian sub-continent is prone to natural disasters. The two weather-related disasters - floods and cyclones-cause heavy losses in terms of human lives and property, and disrupt normal life every year. While there are various organizations under the Central and State governments tackling very diverse aspects of management of these disasters, the scientific inputs in terms of climatological information and real-time observed data for issuing early warnings are provided by the India Meteorological Department (IMD) through its cyclone and rainfall monitoring network. Meteorological aspects of floods in India and the cyclone monitoring and warning procedures are discussed.

1. Introduction

Floods and tropical cyclones account for a greater share of disasters worldwide than all other natural disasters put together, in terms of significant damage, persons affected and number of deaths, as shown in Fig. I. India ranks high among the countries prone to

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hazards of floods and cyclonic storms. Due to its continental size and the inherent variability of its rainfall regime, both over time and space, large rainfall anomalies are found to occur in some part of the country or the other, even if the total rainfall over the country as a whole is near normal. Floods in some part and drought in another are therefore common occurrences in India. Further, the long coastline of peninsular India is frequently affected by cyclonic storms originating in the Bay of Bengal and the Arabian Sea. These natural disasters put the process of development back by several years in the affected areas.

Protective measures against floods and cyclones have been adopted in the country from time immemorial. However, it is in recent times that strategies for complete flood management have been evolved. These include :

(i) Structural measures like embankments, reservoirs, channel improvement and cyclone shelters etc.
(ii) Non-structural measures like flood plain zoning and land use management and cyclone- and flood-proof design of roads, buildings and structures
(iii) Disaster preparedness - contingency plans including community preparedness
(iv) Early warning systems - Flood and cyclone forecasting
(v) Emergency response system like evacuating people, flood fighting and public health
(vi) Flood relief and revenue remission including flood insurance coverage
(vii) Research and Training on all the above components

Most of the above measures are implemented by various departments under the respective state governments because flood is a "state" subject as per the constitution of India. The policies and programmes on floods are formulated by the Ministry of Agriculture, Government of India (nodal agency for natural disaster management) and the Ministry of Water Resources. India Meteorological Department (IMD) is responsible for monitoring and issuing warnings on cyclonic storms and heavy rainfall, and Central Water Commission provides forecasts on floods.

The discussion in this talk will be limited to the Early Warning component with emphasis on the meteorological and climatological aspects of floods and cyclones in India.

2. Phenomena of floods

Various definitions of flood are found in the literature. The term flood is generally used when the flows in rivers or streams cannot be contained within natural or artificial banks. Floods occur when a large volume of water from heavy rainfall, river spill, snow melts, storm surge or breach in embankment etc. is not able to drain off quickly through normal processes of run off and absorption in the ground. Floods in large basins occur normally due to a large amount of rainfall over several days. In small watersheds, floods are generally created by heavy rain of local extent. The factors that may aggravate flood are imbalance between the inflow and outflow of water, inadequate drainage and the ground condition in the sense of its capacity to absorb water. Other factors responsible for abetting floods are river bank erosion and silting of river beds, synchronization of floods in the main and tributary rivers and retardation of flow due to tidal and backwater effects in coastal areas. A short-term rise in water level can also be due to blockage downstream due to boulders, ice slabs or other debris. It may be mentioned that identical flood generating conditions may not create the same type of floods from one catchment area to another or within the same catchment area at different times. These differences arise due to varying flood intensifying conditions. Floods are recurrent hydrological phenomena in India. In the study of floods, it is common to consider the largest flood in each year called the Annual Flood. From the analysis of annual flood data the probability that a certain flood would be exceeded in a year is determined. The recurrence interval of a flood of a given size is known as the Return Period. It is a statistical way of describing the rarity of a flood event. Another parameter is the mean annual flood which is the average of the annual floods. The mean annual flood has a return period of about 3 years. Floods are the most frequent and most widespread of all natural disasters. They result in death,

damage to the habitat and physical infrastructure, erosion of topsoil in hilly areas, excessive siltation in river beds, erosion of river banks and deterioration of sanitation. Thus floods leave behind prolonged ill effects. The greatest sufferers are economically and socially disadvantaged members of the community. Apart from their adverse impacts, floods make significant positive contributions such as land building in flood plains due to siltation, natural fertilization of the flood plain lands, increased recharge of ground water, increased fish production etc.

3. Meteorological aspects of floods

Meteorology and climatology play a pre-eminent role in the study of floods because the basic ingredient – water – comes through rainfall over the catchment area.

3.1. The Hydrologic Cycle

The earth's hydrosphere, i.e. oceans, atmosphere, lakes, rivers, glaciers, soil and living tissues all put together, contains, 1.386 billion cubic kilometers (ckm) of water. The vast bulk of it amounting to about 96.5% of the total is stored in oceans. About 1.76% is blocked up in glaciers, ice and snow and 1.69% in the form of underground water. This leaves less than 0.1 % in fresh water lakes, rivers and streams. A very small fraction stays as water vapour within the atmosphere as shown in Table1. The Hydrologic cycle depicts the continuous movement of water from ocean to atmosphere by evaporation, from atmosphere to land and directly to ocean in the form of precipitation, and from land back to the sea every year through run off as shown in Table 2. There is a near perfect balance between the volume of water evaporated and precipitation, such that the sea maintains its level and the hydrologic cycle appears to be almost eternal. The movement of water through the cycle holds the key to the climatic cycle of monsoon and distribution of moisture over the surface of our planet. However, precipitation is not uniform from season to season, year to year and from place to place due to inherent variability in the above cycle, creating situations of scarcity

(droughts) and excess (floods) of water over some areas for a short duration in the year. In this context meteorology assumes great importance in the study of and operational activities related to floods.

Table 1: Estimated world water quantities (UNESCO-I978)

Item	Volume, km^3	% of total water
Oceans	1.338×10^9	96.537
Ground water	23.4165×10^6	1.6895
Polar ice and others	24.3741×10^6	1.759
Lakes	176.4×10^3	.013
Marshes	11.47×10^3	.0008
Rivers	2.12×10^3	.0002
Atmospheric water	12.9×10^3	.0009
Biological water	1.120×10^3	.0001
Total	1385994610	100

Table 2: Global annual water balance

Item	Ocean	Land	Total
Area, (km^2)	361.3×10^6	148.7×10^6	510×10^6
Precipitation, km^3/Yr mm/Yr	458×10^3 1270	119×10^3 800	577×10^3
Evaporation Km^3/Yr mm/Yr	505×10^3 1400	72×10^3 484	577×10^3
Run-off to ocean & rivers, km^3/Yr	–	44.7×10^3	
Ground water, km^3/Yr	–	2.2×10^3	
Total run-off, km^3/Yr	–	47×10^3	
Total run-off, mm/Yr	–	316	

3.2. Rainfall regime of India

India's long-term average annual rainfall is 116 cm which is the highest in the world for countries of comparable size. The spatial variability of India's annual rainfall is shown in Fig.2 below. It can be seen that rainfall varies from 200 cm (and above) in the North-East and Western Ghats to less than 20 cm in south-west Rajasthan. Cherapunji and Mawsyaram in Meghalaya receive the highest rainfall in the world (11438 mm and 11873 mm respectively). Table 3 shows the percentage area distribution of annual rainfall over India (Kulshreshtha, 2000).

Table 3: Percentage area distribution of annual rainfall over India

Mean annual rainfall, cm	Corresponding % Area
0 - 75	30
75 - 125	42
125 - 200	20
> 200	8

All this rainfall is not evenly distributed in time. About 80% of the total rainfall over India comes during the south-west monsoon season with the exception of Tamil Nadu which gets about 40% rainfall during the south-west monsoon and a major portion during the north-east monsoon months of October to December. The remaining rainfall results from 'western disturbances' during December to February in the northern parts of the country and due to cyclonic storms over the coastal belt during the pre- and post- monsoon period.

Rainfall during the summer monsoon season (June to September) occurs due to the following synoptic (meteorological) situations:

(i) Monsoon trough extending over north India from north-western parts of the country to West Bengal and its movement during the season. Rainfall occurs mainly south

of the trough. When the trough moves over the foothills of the Himalayas it brings rainfall in that region. Under such conditions, rainfall reduces in central and northern India, a situation known as break-monsoon condition. Rivers in the foothills overflow and cause floods in the plains even without much rainfall locally.

(ii) Depressions form in the Bay of Bengal during the monsoon and move north-westward or westward over the land along the monsoon trough axis. These systems bring heavy rainfall along their track often causing severe floods.

(iii) Strengthening of the Arabian Sea monsoon current causes vigorous monsoon conditions bringing heavy rainfall over the Western Ghats area.

3.2. Monsoon variability

Records of rainfall measurements over more than 125 years are available in the data archives of the India Meteorological Department. Fig 3 below shows the annual performance of monsoon rainfall over the country for the period 1875-2000. It shows that in a majority (86%) of cases the annual monsoon rainfall is within the normal limits or in excess by ± 10% of the long-term average. Out of these, during 16 years the rainfall was in excess of 110% of the limit. Noteworthy among the excess rainfall years were the following:

Table 4 Monsoon variability

Year	% area of the country with excess rainfall	Total monsoon rainfall, %	Remarks
1892	47	116	Prominent flood year
1917	53	118	Worst flood year
1956	29	115	Prominent flood year
1961	49	120	Worst flood year
1988	49	116	Prominent flood year

Thus, it is clear that there are fluctuations in the total monsoon rainfall from year to year for the country as a whole. The reasons for this variability include variation in the date of onset and withdrawal of the monsoon, break-monsoon conditions and variation in number of monsoon depressions. The variability is also pronounced over space. The rainfall distribution over space can be erratic bringing excess rain in one part of the country and deficiency in another, depending on the number and tracks of monsoon depressions over the respective areas. The variability of the Indian summer monsoon both in time and space is currently a subject of intense scientific research.

3.4. Severe rainstorms

Severe rainstorms due to depressions during the monsoon or cyclonic disturbances are common in India. The rainstorms can bring rainfall of 40 to 80 cm in 24 hours and can affect large areas covering hundreds of thousands of square kilometers. The severest rainstorm on record is that of Dharampur in Surat in Gujarat due to a monsoon depression on 2nd July 1941, which brought 99 cm of rainfall in 24 hours. Severe rainstorms can occur over any part of the country including over arid areas and even during drought years. The severest storm of 2nd July 1941 mentioned above is one such example. These rainstorms have considerable flood potential. Hydrologists use the information on rainstorms in terms of (i) amount of rainfall (depth), (ii) area over which rainfall occurs and (iii) duration of rainfall, called Depth-Area-Duration (DAD) analysis.

4. Flood scene in India

Rashtriya Barh Ayog (National Commission on Floods - 1980) has adopted the classification of river basins of the country by Framjee and Garg (1976). According to this classification India's rivers are divided into four groups on the basis of similarity of meteorological, geological and topographical conditions and hydrological characteristics of the rivers and tributaries. The salient features of these groups are given below:

(i) Brahmaputra river region

- Main rivers-Brahmaputra and Barak
- Comprises north-eastern parts of India
- Catchment area about 1 millian sq.km.
- Maximum discharge - 73620 m^3/sec
- Annual rainfall - 180 cm to 640 cm
- High silt load
- Tendency to change course
- Enormous flood problems in north-eastern states of India.

(ii) Ganga river region

- Comprises north India
- River Ganga dominates with numerous tributaries including river Yamuna in the Himalayas and the Indo Gangetic plains (covering Uttaranchal, UP, Bihar and West Bengal)
- Catchment area- 1.07 million sq.km
- Maximum recorded discharge - 70790 m^3/sec
- Rainfall in catchment varies between 60 and 190 cm with 80% in the monsoon season. Predominant flood problem in northern or left bank. Most of the damage caused by northern tributaries.
- Flood problem more pronounced in tributaries in the east, especially in the rivers of north Bihar.

(iii) North-west river region

- Main rivers Sutlej, Beas, Ravi, Chenab and Jhelum - all tributaries of Indus
- Catchment of the Indus in India - about 321289 km^2. Floods mainly in Jhelum, particularly the left bank, inundating cultivated lands around Srinagar due to inadequate outflow capacity.
- Floods also experienced in Punjab, Haryana and adjoining parts of Rajasthan due to a large number of hill torrents and streams spilling into the plains during the monsoon. Overall the problem is smaller and less frequent.

(iv) Central India and Deccan river region

- Main rivers - Narmada, Tapti, Mahanadi, Godavari, Krishna and Kaveri mostly have a well-defined, stable course.
- During heavy monsoon rainfall Narmada and Tapti get flooded affecting Gujarat. Floods in the Mahanadi, Godavari and Krishna during monsoons/cyclones affect Andhra Pradesh and Orissa. Floods in Kaveri affect Karnataka and Tamil Nadu.
- Floods more pronounced in deltaic region.

According to the estimates of RBA (1980) and Flood Atlas of India (CWC, 1987), about 34 million hectares of land (about 10% of the area of the country) are prone to floods. An analysis of flood data shows that Assam and Bihar are the worst affected states followed by Uttar Pradesh and West Bengal. The rivers of Central and Peninsular India experience floods to a lesser extent. The state of Orissa is also prone to floods, both during the monsoon and due to cyclonic storms. While more than half of Punjab is prone to floods, less than half of Haryana and West Bengal and about a quarter of Bihar and Uttar Pradesh are prone to floods.

Although there are less frequent floods in Central India, the cases of most severe floods (5 metres or more above danger level) are more numerous in this region as compared to north and north-east India. The highest flood on record in India occurred on 4 October 1968 at Anderson Bridge gauge/discharge site on river Teesta in sub-Himalayan West Bengal when the level rose to 18.1 metres above the danger level at the site. It may be noted that often, most severe rainstorms may not result in most severe floods on record in the area. Severity of flood at any location is a function of many factors such as intensity and extent of rainfall, antecedent conditions of catchment, physical characteristics of the river, topography etc.

In many cases the natural process of flooding is aggravated by man-made obstacles to free outflow/absorption of flood water

both in cropland areas as well as in urban areas with unplanned construction activity. The most widespread floods in recent times occurred during the monsoon of 1998 as a result of a well-marked low/depression which traversed the breadth of the country during the second week of September from the West Bengal/Orissa coast upto Gujarat bringing incessant and widespread rains. Much of the flood water remained confined due to the network of embankments, roads and elevated rail tracks. About 40000 hectares of cropland remained under flood waters for about two months.

The increased availability of flood water and fresh nutrients brought with the silt have some helpful effect on agriculture after the flood. Figs. 4 and 5 show that during the years of excess monsoon rainfall, the foodgrain production in the country receives a definite boost. Even where the monsoon crop (Kharif) is totally destroyed, there is increased production in the Rabi crop after the monsoon resulting in higher agricultural production as a whole.

5. Flood forecasting and warning systems:

The responsibility to issue flood forecasts in India rests with the Central Water Commission (CWC). Inputs to the forecasting of floods come from two agencies - CWC with its gauge/discharge stations over all rivers and IMD with its rainfall measurements over the catchment areas. The steps involved in flood forecasting by CWC are as follows:

(i) Collection and transmission of hydrological and hydro-meteorological field observations

(ii) Data processing and formulation of forecasts for river stage and its time of occurrence by 157 flood forecasting stations of CWC

(iii) Dissemination of flood forecasts and warnings by CWC

(iv) Monitoring and evaluation procedure (permissible error ± 15 cm).

CWC claims an overall accuracy of 90-95% for its flood forecasts. It may be mentioned in this context that both general forecasts for heavy rainfall by IMD as well as the flood forecasts by CWC are at present made for a macro level covering wide areas. There is need to expand the system to cater to remote and hill areas and basins served by small streams where flood problems are recurrent. This can perhaps be done more efficiently with participation of the local community in the programme of observation, dissemination of warnings and management during floods.

6. Cyclonic storms

Cyclonic storms are the most destructive atmospheric phenomena taking a toll of thousands of lives and destroying property worth thousands of crores of Rupees each year around the world.

Records show that about 80 tropical cyclones form over the globe every year. The parts of the oceans over which these storms form and the periods of peak activity are shown in Fig. 6. These intense tropical storms are known in different parts of the world by different names. In the Pacific they are called 'Typhoons', in the Indian Ocean they are called 'Cyclones' and over the North Atlantic they are called 'Hurricanes'. The number of storms which form over the northern part of the Indian Ocean (NIO), i.e. the Bay of Bengal and Arabian Sea, is five to six per year on average, which is about 7% of the total number over the globe. More cyclones occur over the Bay of Bengal than over the Arabian Sea, roughly in the ratio of 4:1. On an average 2-3 cyclones affect the coastal belt of India every year. The three elements which cause destruction during a cyclonic storm are (i) high winds often exceeding 200 km/hr., (ii) heavy rainfall reaching upto 50 cm in a day and (iii) storm surge or the wave of sea water generated by the storm which, depending on the point of landfall, can be as high as 7 metres over and above the normal (astronomical) tide. Storm surge is by far the most deadly feature of a tropical cyclone. Despite their immensely destructive nature over the area of landfall, cyclones bring in widespread rainfall over vast land areas, useful for agriculture and replenishment of water resources.

6.1. Classification

The term 'Cyclone' is a generic term covering all the four atmospheric disturbances, namely, low pressure areas, depressions, deep depressions and cyclonic storms. The new nomenclature introduced by IMD in 1998 for description of cyclonic disturbances in the NIO is given in Table 5.

Table 5: New classification of cyclonic disturbances and storms in IMD

IMD classification	Wind speed	
	Knots	kmph (approx.)
Low Pressure Area	Less than 17	31
Depression	17 to 20	31 to 51
Deep Depression	28 to 33	52 to 62
Cyclonic Storm	34 to 47	63 to 87
Severe Cyclonic Storm	48 to 63	88 to 117
Very Severe Cyclonic Storm	64 to 119	118 to 221
Super Cyclonic Strom	120 and above	222 and above

6.2. Formation and structure of a cyclonic storm

A tropical cyclone is like a giant heat engine fuelled by the latent heat liberated when huge quantities of water vapour condense. The release of latent heat further warms up the air which rises up creating a drop in pressure near the surface. This gives rise to rapid inflow of air creating a warm core atmospheric vortex. To get this engine started a large quantity of warm moist air is required. Continuous supply is needed to keep it going. This is possible under certain conditions over vast stretches of ocean, namely, (i) sea surface temperature must be higher than 27 degrees C, (ii) sufficiently large sea area to provide a continuous supply of warm moist air, (iii) the location should not be near the equator between 5^{0}N and 5^{0}S where the Coriolis force due to earth's rotation is

low and (iv) a pre-existing low level relative vorticity or weak low pressure area which should acquire a warm core through the troposphere with upper divergence above the sea level system.

Before attaining maturity a cyclonic storm passes through the 'formative stage' and the 'immature stage'. In the formative stage genesis of the cyclonic circulation around a pre-existing shallow low pressure area takes place. The circulation picks up and the system develops into the stages of 'depression' and 'deep depression'. As the system strengthens further, spiralling bands of rainbearing clouds extend outward from the central region. During this phase of development, winds from a very large area are drawn into circulation. Low level convergence increases and divergence at the upper levels of the storm sets in. Rapid fall of central pressure and increased intensity of circulation occur simultaneously.

All through its development, a storm travels slowly at a rate of about 300 km to 500 km per day till it crosses over a land mass. During the course of its movement over the ocean, a cyclonic storm can further intensify into a Severe Cyclonic Storm (SCS). The 'eye' of the storm appears when the wind exceeds 64 knots and a wall cloud develops in the zone of intense convection. It can further intensify into a Very Severe Cyclonic Storm (VSCS) and a Super Cyclonic Storm defined in Table 1 above.

The average life-span of a cyclonic storm in the NIO is about 1.5 days. After landfall the cyclonic storm may rapidly decay into a depression within a day, after which it can continue to move over land for a few days.

A fully matured cyclonic storm is a great whirlpool in the atmosphere often upto 15 km tall. The tropospheric vortex may extend over 150 to 1500 km horizontally. Within the vortex, strong winds of gale force circulate in an anti-clockwise direction in the northern hemisphere and in a clockwise direction in the southern hemisphere. At the lower tropospheric level, considerable inflow of air (convergence) takes place. The innermost part of the eye of the storm having a diameter of 5 to 50 km has relatively calm winds and is free from clouds. The temperature in the core

is higher than the surroundings at higher levels. The temperature anomaly is less at the surface than at higher levels and can be 16 to 17 degrees C at 250 hPa. The wind decreases slowly with height upto about 6 km and more rapidly thereafter. The top layer of the storm above 6 km is the outflow layer where the winds are directed outwards. The pressure fall in the eye of the cyclone in the lower level can be as much as 100 hPa.

6.3. Climatology of cyclonic storms over the NIO

Knowledge of the behaviour of past cyclones, point of formation, tracks over the oceans, the point of landfall and frequency of occurrence through different seasons is very helpful not only for cyclone forecasting but also for the purpose of risk assessment of a given area for disaster preparedness. India Meteorological Department has collected climatological data on cyclones for over a century and brought out an atlas on "Tracks of storms and depressions in the Bay of Bengal and the Arabian Sea for the period 1877-1970". The work has been extended by Mandal (1991) upto 1989. Annual reports giving details of cyclonic disturbances over NIO are being brought out by IMD (RSMC-Tropical Cyclones, New Delhi) 1990 onwards.

The chief feature of tropical cyclones observed in the NIO is the bimodal characteristic of occurrence in the year with a primary peak in November and a secondary peak in May as shown in Fig. 7. This greatly helps in confining and concentrating disaster preparedness efforts to the two "Cyclone Seasons". Past records show that 24-Parganas in West Bengal is more vulnerable to cyclones followed by Nellore in Andhra Pradesh. Considering the year as a whole, the Orissa and West Bengal coasts have the highest number of storms. The preferred coasts in the post-monsoon period are in Tamilnadu and Andhra Pradesh whereas West Bengal and Orissa are hit more in the summer and monsoon season.

Depending upon the season and the latitude of their formation, the storms move towards the coastal areas of the Indian sub-continent following some characteristic tracks. Thus the likely

track of a storm can be forecast with some degree of confidence based on the climatology of storm tracks.

7. Cyclone observing system in IMD

The India Meteorological Department consisting of 559 surface observatories and 100 upper air observatories (65 pilot balloon and 35 radiosonde/radiowind observatories) supports a country-wide network of stations for collection of synoptic meteorological data.

To help detection and tracking of cyclones, IMD maintains a network of ten Cyclone Detection Radars, each with a range of 400 km covering the entire coastline of India. The main facility at present being used by IMD for monitoring satellite cloud imagery is based on INSAT Application Programme which includes meteorological support for meeting IMD's requirement of weather analysis and forecasting. A Meteorological Data Dissemination (MDD) system is operational. Under this scheme, processed satellite imagery is being multiplexed with meteorological data and weather facsimile charts and uplinked to INSAT in the C-Band for reception at 25 ground stations in S-Band.

IMD enlists voluntary observing ships and provides necessary instruments for collection of meteorological observations from ocean areas during their routine sails. These observations are received in real time at the storm warning centers and are found extremely useful in cyclone forecasting work. Meteorological data from ocean areas (Bay of Bengal and Arabian Sea) has started coming to storm warning centers of IMD from the National Data Buoy Programme of DOD-NIOT.

7.1. Meteorological Telecommunication System

IMD maintains an extensive telecommunication network connecting national and international meteorological centres for exchanging observed data and processed information. The field

stations are linked with 19 Met. Centres in the state capitals and with five Regional Collection Centres equipped with Automatic Message Switching System (AMSS) through one or more of the following modes of communication - landline telegrams, point-to-point teleprinter circuits (97), telex (85), Radio Tele Type (RTT) reception (27), HFRT (63), VHF (47) and telefax (66). The observed data are received in coded form at forecasting storm warning centres and at the central Regional Telecom Hub at New Delhi through 2400 bps links. A network of twenty satellite-based VSAT communication systems exists at major centres as a standby channel in case of failure of conventional systems. The processed information in the form of meteorological charts containing analysis and prognosis prepared by the Regional Specialised Meteorological Centre (WMO) at the Northern Hemisphere Analysis Centre, IMD is broadcast by means of facsimile equipment. Facsimile reception facilities are available at 27 stations at present. The facsimile broadcast covers a radial area of about 5000 km and is received by many countries in Europe, Africa, Asia and Australia and especially by countries affected by cyclones in the NIO.

8. Tropical cyclone forecasting methods

The two most important and fundamental aspects of tropical cyclone forecasting are prediction of the *track* and *intensity* of cyclones. The remaining details can then be derived for advance warnings and disaster management purposes. These include time and location of landfall, estimated height of storm tides and the areas likely to be hit, the area likely to be inundated by heavy to very heavy rainfall and the damage potential due to strong winds. Operational track prediction is done in IMD using statistical models based on climatology, persistence, CLIPER, analogue, synoptic techniques and Numerical Weather Prediction model.

Intensity prediction is done using cloud imagery in visible and infrared based on the technique developed by Dvorak (1984). Satellite imageries offer the only source of estimation of intensity and position in the data sparse regions of NIO when the cyclonic

storm is beyond the reach of cyclone detection radars (> 400 km).

Before the advent of satellites, advance detection of cyclones was possible only with radars. As the cyclonic storms are large in size horizontally, the radar echoes may begin to show pre-hurricane squall lines, outer convective bands and well-developed spiral bands of an intense storm when the centre is far beyond radar range. The eye of a well-developed cyclonic storm may be detected by radar at a distance as large as 300 km.

9. Storm surge

About 90% of all cyclone-related deaths are due to the passage of storm surges over the coastal areas where the eye of the cyclonic storm makes landfall. A storm surge is a dome of water 65 to 80 km wide, raised above the sea level primarily due to the wind stress generated by an intense tropical cyclone. Combined with the astronomical high tide, the total height of storm tides for some coasts in the Bay of Bengal could be as high as 13 metres and can penetrate several kilometers inland sweeping away whatever comes in the way. The height of storm surge varies for different coastal areas and therefore the problem of prediction becomes very important for optimizing the disaster mitigation effort. The numerical technique of storm surge prediction consists of solving the hydrodynamic equations governing the motion in the sea driven by winds of a cyclonic storm. The storm surge model developed by Ghosh (1977, 1995) has been adopted by IMD for operational use. Based on this model, maximum probable storm surges at coastal towns of India have been shown in Fig.8.

In this method, the expected peak surge is computed using three nomograms from which the surge height and corrections can be quickly read off for operational use during cyclone situations. Although accurate measurements of storm tides are not available for Indian coasts, the error in forecast storm surge height compared to heights estimated from indirect observations is within ±0.5 m for different places along Indian coasts.

10. Cyclone warning organisation

Cyclone warnings in India are provided through three Area Cyclone Warning Centres (ACWCs) located at Calcutta, Chennai and Mumbai, and three Cyclone Warning Centres (CWCs) at Bhubaneshwar, Visakhapatnam and Ahmedabad. The organizational structure for cyclone warning is multi-tier. ACWCs / CWCs actually perform the operational work of issuing warnings to various users. The weather Forecasting Office of IMD at Pune coordinates and guides the work of ACWC / CWCs and the Cyclone Warning Division at IMD HQ New Delhi co-ordinates the work at national and international levels.

10.1. Cyclone Bulletins and Warnings

When a depression intensifies into a cyclonic storm and is likely to affect the Indian coast, the following warnings and bulletins are issued by IMD HQ, ACWCs and CWCs to the user agencies: (a) Sea Area and Coastal Bulletins, (b) Two-stage Warnings, (c) Port Warnings, (d) Fishermen Warning, (e) Bulletins for All India Radio / Doordarshan, (f) Bulletins for the press, (g) Registered users warnings and (h) Aviation hazard warning.

In India, cyclone warnings are issued in four stages (earlier known as 2-stage warnings) to Collectors of coastal and neighbouring districts and the Chief Secretary of the concerned maritime state with information on (i) heavy rainfall, (ii) gales and (iii) storm surge (tide). The first-stage warning, known as "pre-cyclone watch", is issued by the Cyclone Warning Division of IMD HQ to all key central and concerned maritime functionaries as soon as a depression forms over the adjoining seas. "Cyclone Alert" is used 48 hours in advance of the expected commencement of adverse weather over the coastal areas by the concerned ACWC / CWC. The second-stage warning, known as "Cyclone Warning", is issued 24 hours in advance. In addition to the forecast for heavy rains and strong winds, the storm surge and landfall point are also forecast in this stage. A "Post-landfall outlook" bulletin is issued by the respective ACWC / CWC starting 12 hours before landfall for the benefit of relief officials of inland areas

which may be affected by the adverse weather due to the cyclone / depression travelling inland.

10.2. Dissemination of cyclone warning message

In addition to broadcast through All India Radio and television, cyclone warning advisories are also sent through highest priority landline telegrams, telephone, telex, police wireless and VSAT etc. A very dependable scheme for transmission of cyclone warning messages, called Cyclone Warning Dissemination System (CWDS) is operational in India since January 1986, now consisting of 250 satellite-based direct receiving systems located along the coasts for the use of cyclone distress mitigation officials. The warning message in English and the regional language originating at CWC / ACWC is transmitted to a satellite which in turn, broadcasts it for instantaneous reception by receiving sets. By a system of selective addressing, warning messages are received only by those receivers for whom they are intended.

10.3. Role of IMD in WMO Tropical Cyclone Programme

Realising the importance of an effective cyclone warning and disaster mitigation machinery in the region of NIO, WMO and ESCAP jointly established the Panel on Tropical Cyclones in 1972 as an inter-governmental body comprising Bangladesh, India, Myanmar, Pakistan, Sri Lanka and Thailand. Later, Maldives joined the panel in 1983 followed by the Sultanate of Oman in 1997, raising the membership of the panel to eight. The main objective of the panel is to promote measures to improve tropical cyclone warning systems in the Bay of Bengal and the Arabian Sea. A "Regional Specialised Meteorological Centre (RSMC) - Tropical Cyclones" has been set up at IMD headquarters at New Delhi under the programme to co-ordinate various activities.

11. Concluding remarks

Floods and cyclones result in very severe damage to life and property in India and cause sudden disruption to normal life. While

the causes are natural and on such a scale that it is impossible to completely prevent them from happening, their adverse effects can be reduced by providing detailed information about these phenomena for proper planning of habitats, and by developing and issuing early warnings for public safety. India Meteorological Department has been able to achieve this aim to a large extent by providing real-time and forecast information on monsoon, rainstorms and cyclonic storms. There is significant reduction in the number of deaths due to these natural calamities after the adoption of satellite technology. Efforts are on to narrow down the area and time of forecasts for more efficient action by the user agencies.

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C C PATEL

Water Resources Management and Water-Related Disasters

A. Water Resources Management

1.0 Water – An Overview

Water is a prime natural resource, a basic human need and a precious national asset. The extent to which water is abundant or scarce, clear or polluted, beneficial or destructive, has a major influence on the quality of human life. The ever-increasing demand for water on the one hand and the deteriorating quality of water by pollution on the other have already created serious problems. Although water is a renewable resource it is also a finite one. Water can no longer be taken for granted. It has to be treated as a valuable and scarce resource. Available water must, therefore, be optimally harnessed and used most beneficially under appropriate priorities.

Wisely used water means harvest, health, prosperity and ecological abundance for the people and the nations on the Earth. When badly managed or out of control, water contributes to economic

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underdevelopment, poverty, disease, flooding, drought, erosion, salination, waterlogging, silting, environmental degradation, and human conflict.

2.0 Water Resources Management:

2.1 Introduction

India suffers from a flood-drought-flood syndrome. While one-third of the country is prone to droughts, over one-eighth is prone to flooding. In spite of periodic resolves, clean drinking water has not yet reached a large part of the rural population. Problems of pollution of water, both surface as well as ground, are on the increase. Irrigation management leaves considerable scope for improvement. Efficiency in water use is very low. Water allocation amongst different uses and different regions is almost chaotic. The existing legal framework for water management is not conducive to optimum development and management. There are many examples of over-exploitation of ground water resulting in ingress of salinity or severe depletion in availability. Man-made activities are changing the morphology of the river systems. Flood damage has been on the increase. India has severe limitations with regard to availability of suitable sites for storage of river water. The problems of rehabilitation of displaced inhabitants of the area are becoming more and more difficult. Participatory irrigation management has just started and is in its infancy. Environmental problems are on the increase. The country can ill afford to brook any further delay in tackling these critical issues. Any inaction or ineffective efforts can lead to great disaster affecting many parts of our country suffering from absolutely scarce water supply, severely hampering human welfare, economic development, human health, and human values. This can put the country's clock back by decades in the present era of global competition.

Normally, good water management should lead to greater and superior water use but lack of it can usher in an era of disaster. Such disaster is not Nature's fury but is man-made. Its prevention is a Herculean task and a great challenge. Far-reaching reforms are necessary nationwide. People need to be made aware of the grim situation likely to develop in the future.

We have not been able to channelise the water development programmes under the framework of the master plans for the development of water of intra-state rivers for each state or for the country for the inter-state rivers. There is also an international dimension, which holds great potential to increase the water supply available to our country and simultaneously contribute to good-neighbourly relations including inter-dependence of the South Asia region. The development of South Asia would also thereby be accelerated, leading to greater stability and security in the region.

2.2 Water development of our country

Good headway has been made on the development side but much more needs to be done by way of resolution of water disputes and eliciting cooperation of basin States. Management of water is the weakest aspect.

Further, food production has to match the needs of the growing population, whose quality of life has been improving. All this calls for Himalayan efforts on each front, including vital reforms, which are called for in the National Water Policy, preparation of master plans and planning implementation and management of water resources. Total reforms are necessary. Environmental issues have to be given much more attention and the design of projects should incorporate ameliorative measures to minimize the environmental impact. Environmental problems can be best solved in an atmosphere of understanding between project authorities and the affected persons, and require a human touch for speedy resolution.

Water reforms have now become a global issue since the problems and issues are more or less similar. The real basic issue, however, is a change in the mindset of the people. Secondly, willingness to pay for water is lacking. Water is no doubt an economic as well as a social good but this does not mean that it is a free commodity.

3.0 Surface Water Availability

Water availability in India versus that in the World.

The global scenario vis-à-vis position of India for the year 2000 is given below in Table 1-A and Table 1-B.

Table 1-A

The scenario of land and water resources of India versus those of the entire World.

Sl. No.	Population (%)	Land Resources (%)	Water Resources (%)	Remarks
World	100	100	100	
India	16.00	2.45	4.00	

Table 1-B

Surface Water Resources (mm^3) in India

Sr. No.	State/ Region	Natural runoff (mm^3)	Population (2000) (Nos)	Per capita availability (2000) (m^3/year)	Remarks
1	India	1,953,000*	1,000,000.00	1953	*As estimated by National Commission on Integrated Water Resources Development Plan,1999 (NCIWRDP)

The distribution of water resources in the country is highly uneven over space and time. Over 80 to 90 percent of the runoff in Indian rivers occurs in four months of the year. There are regions of harmful abundance and also acute scarcity. Vast populations live in the latter areas.

3.1 Climate and rainfall

The climate of India is greatly influenced by the presence of the great mountain mass of the high Himalayas in the north and the ocean in the south. The sub-continent experiences both tropical and oceanic climates, ranging from extreme heat to extreme cold, from aridity and negligible rainfall to excessive humidity and torrential rainfall. The climatic conditions influence to a great extent the distribution of the water resources of the country.

The rainfall in the country depends on the southwest, retreat and northeast monsoons, shallow depressions and disturbances, violent local storms, and occasional cyclones. Most of the rainfall in India occurs as a result of the southwest monsoon between June and September, except in the State of Tamil Nadu, which falls under the influence of the retreat and northeast monsoon during October and November. Rainfall patterns vary greatly depending on the season and the region.

All-India average rainfall is 1,170mm, but it varies from 100 mm in the Western deserts to 11,000 mm in the North-Eastern region. More than 50 percent of precipitation takes place in about 15 days and less than 100 hours altogether in a year. The rainy days may be only about five in deserts to 150 in the North-East.

3.2 Surface water

The average annual precipitation in India including snowfall has been estimated as 4,000 km . Some of this originates

beyond our borders, and some of it crosses our borders on the way to the sea and goes into the downstream countries.

3.3 Ground water

The annual availability of ground water is determined by the annual recharge of the aquifer (and further recharges over a period of 3 to 5 years). It follows that water extracted from an aquifer in any year should be capable of being replenished through recharge from the succeeding precipitations (or other recharge), so that over a cycle of 2, 3 or 5 years, the groundwater table does not go down. When there is over-exploitation of groundwater (which is technically known as mining), the water table goes down progressively. Such over-exploitation has occurred in several places in our country, and has caused ingress of saline water from the sea in some coastal areas.

Table 1-C

Mean Flow Utilizable Surface and Ground Water Resource – Basin-Wise

Sl. No.	River Basin	Mean Flow Surface Water BCM	Utilizable Flow Surface Water BCM	Repleni-shable Ground Water BCM	Utilizable Ground Water BCM
1.	**2.**	**3.**	**4.**	**5.**	**6.**
1	Indus	73.31	46.0	26.50	24.3
2a	Ganga	525.02	250.0	171.000	156.8
2b	Brahmaputra	629.05	24.0	26.55	24.4
2c	Barak	48.36	-	8.52	7.8
3	Godavari	110.54	76.3	40.64	37.2
4	Krishna	69.81	58.0	26.40	24.2

5	Cauvery	21.36	19.0	12.30	11.3
6	Subernarekha	12.37	6.8	1.82	1.7
7	Brahmani-Baitarni	28.48	18.3	4.05	3.7
8	Mahanadi	66.88	50.0	16.50	15.1
9	Pennar	6.32	6.9	4.93	4.5
10	Mahi	11.02	3.1	7.20	6.6
11	Sabarmati	3,81	1.9	-	-
12	Narmada	45.64	34.5	10.80	9.9
13	Tapti	14.88	14.5	8.27	7.6
14	West-flowing rivers between Tapti and Tadri	87.41	11.9	17.70	16.2
15	West-flowing rivers between Tauri and Kanyakumari	113.53	24.3	-	-
16	East-flowing rivers between Mahanadi and Pennar	22.52	13.1	11.22	10.3
17	East-flowing rivers between Pennar and Kanyakumari	16.46	16.7	18.00	17.2
18	West-flowing rivers of Kutch and Saurashrta and Luni	15.10	15.0	0	0
19	Area of inland drainage in Rajasthan	0.00	-	0	0
20	Minor rivers draining into Bangladesh and Myanmar	31.00	-	18.12	16.8
	Total	**1952.87**	**690.3**	**431.32**	**395.6**

3.4 Replenishable groundwater resource

This is estimated at 432 km^3 while utilizable groundwater resource is 396 km^3.

4.0 Water Requirement – Issues And Concerns

Population and water stress

Malin Falkenmark, a widely respected Swedish hydrologist and pioneer in the concept of water stress index, has opined that a country whose renewable fresh water availability on annual per capita basis exceeds about 1700 m^3 would suffer from occasional local problems. Below this threshold the country begins to experience a period of regular water stress. When fresh water availability falls below 1000 m^3 per person per year, the country would experience chronic water scarcity, which hampers economic development, human health and value. When the availability falls below the 500 mark, the area would experience absolute scarcity. The 21st century would pose problems of survival itself in these regions. This therefore, underscores both the need to import water in water short regions as well as the imperative of making the most efficient and beneficial use of available water by resorting to the most efficient and appropriate management strategies.

5.0 Uses of Water

Uses can be broadly classified as (I) offstream use and (II) instream use. Offstream use comprises use for irrigated agriculture, domestic and industrial water supply, thermal and nuclear power generation, etc. Instream use comprises use for hydroelectric power generation, fisheries, navigation, recreation, etc. Water withdrawn for offstream use consists of two components (a) the part returned to the surface water or to ground water aquifers after use and (b) the part consumed or not returned to the source after use. A typical example of consumptive use is transpiration by vegetation and evaporation from wet soils. Much

of the water used for efficient irrigation is either transpired by the plants or evaporated from the soil.

6.0 National Water Policy

The National Water Resources Council was set up in the year 1982 with the Prime Minister as Chairman and Chief Ministers of States as members. A broad policy on water was agreed upon in the Council in 1987. This indeed, was a major milestone towards rational and optimum development and management of water. The water policy was reviewed recently. The revised water policy is no doubt a step forward from the earlier one approved in September, 1987.

It is now urgently necessary to lay down detailed principles and criteria for allocation of water and its use. This is no doubt a stupendous task involving, as it does, study of the performance of the existing projects, existing legal framework, decisions of the Water Dispute Tribunals and precedents regarding use of waters of inter-state rivers.

Principles (known as Helsinki rules) are evolved by the International Law Association (ILA) and the International Law Commission (UN). Fortunately, sound legal principles have now been laid down by the Water Dispute Act, and have been applied to specific projects under dispute. However, a lot of work is required on the legal, economic and technological side so as to define precisely the water-sharing principles and mechanism in order to resolve/reduce water disputes, which at present are vitiating good-neighbourly relations amongst various States and affecting adversely the unity of the country. Traditionally our country has many divisive issues which retard progress and impede the emergence of healthy democracy. Let us at least do our best to resolve and minimize water disputes in the interest of optimal use of the limited waters of our country, and in the larger national interest. The aim should be to prepare a long-term master plan for development and use of India's scarce and valuable water resources, adopting appropriate principles of allocation among

different uses and different regions in accordance with a well-defined water policy. An institutional structure needs to be created for formulation of detailed policy criteria to enable preparation of further plans for development of water, and for implementation, management and review from time to time. The National Water Policy cannot be a static document. It has to change with time to meet the changing needs of the nation.

Such a plan could then be placed before the National Water Development Authorities for consideration and acceptance.

7.0 Water Requirement

Water requirement for irrigated agriculture and domestic needs including drinking, cooking, sanitation, and municipal services (urban as well as rural) and for trade, commerce and industries, energy, ecology and afforestation together constitutes the bulk of the total water consumption. The requirement is closely related to population, demand for food, production of non-food agricultural and industrial items, production of energy, and for improvement in the quality of life and for preserving the ecology of the nation.

7.1 Total water requirement

The estimated water requirements for different uses have been assessed by the National Commission on Integrated Water Resources Development Plan (NCIWRD) and are given in Table 2 below:

Sl. No.	Category	Year 2010			Year 2025			Year 2050		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
1	Irrigation	489	536	556	619	688	734	830	1008	1191
2	Domestic	39.4	41.6	61	47	52	78	59	67	104
3	Industries	3.7	37	37	61	67	79	69	81	116
4	Energy	4.1	4.4	5.0	11.0	12.0	13.0	37.0	40.0	44.0

5	Inland Navigation	-	-	-	4	4	4	7	7	7
6	Flood Contro	-	-	-	-	-	-	-	-	-
7	Afforestation	33	33	33	67	67	67	134	134	134
8	Ecology	5	5	5	10	10	10	20	20	120
9	Evaporation	36	36	36	42	42	42	65	65	65
10	Total	644	693	733	861	942	1027	1221	1422	1621

Irrigation consumes over 80% of the waters in our country. During the last 50 years major programmes for irrigation as well as water supply have been launched. These include multi-purpose major, medium and minor surface irrigation schemes/ground water schemes. These have been implemented and are being operated.

7.2 Irrigation

This consumes the largest quantum of water, viz. about 80%. Hence its management needs greater attention. Any water saved by irrigation can benefit many more people or industries, whose requirement is about 10% of the irrigation requirements.

The following scenario existed at pre-plan and end Ninth Plan (1997-2000) :

Plan	Major/medium Irrigation		Minor Irrigation		Total Irrigation		Remarks
	Potential	Utilization	P	U	P	U	
Pre-plan	9.7	9.7	12.9	12.9	22.6	22.6	
Ninth Plan 1997-2002 (Proposed)	42.77	36.15	69.84	57.24	106.61	93.39	
Ultimate Irrigation potential/ utilization	58.46	58.46	81.43	81.43	139.89	139.89	

Note : Major Irrigation – c.c.a: > 10,000 ha
Medium Irrigation – c.c.a:> 2,000-10,000 ha
Minor irrigation – c.c.a < 2,000 or less

We have reached 60% of the potential for major/medium projects and about 70% for minor irrigation.

7.3 Issues and concerns

The entire programme including investigation, planning, design, implementation and operation has been successfully handled by the professionals of our country without any significant assistance from foreign consultants. This has not only accelerated the completion of projects but also trained a large number of upcoming irrigation engineers in planning and design.

There are a number of issues which have already arisen during implementation, especially in major projects, such as time and cost overruns and issues regarding displacement and rehabilitation of project-affected persons, benefits falling short of original expectation, lag in utilization of potential created, poor financial returns, poor operation due to lack of funds, questions of equity amongst different regions, between the PAPs and beneficiaries, between the farmers in head reaches and those in tail reaches, water disputes, legal issues etc.

In the future, the current concerns and issues in the development of the irrigation sector will grow unless appropriately tackled. Finite availability of water in the face of increasing demand and deteriorating quality would also give rise to too many new issues and concerns. We must, as a priority, put our own house in order first. We must grapple with the main issues of equity and efficiency in irrigation management. These, in turn, hinge on the strength and flexibility of our legal and institutional mechanisms, the economic and technological choices that we make, and the strategies for water management that we adopt and modify to suit the situation. This is indeed a dynamic situation calling for specific solutions for different projects/systems and at different times. A holistic view has to be taken keeping in mind the most efficient and beneficial use of water in the larger interest of the greatest number.

7.4 The basic problem

The irrigation and drainage management issues facing India are common to many developing countries. They largely relate to public sector - managed surface irrigation systems and comprise numerous physical, institutional and financial/economic constraints. These issues are required to be addressed at the State level since irrigation is a State subject.

In the post-independence era major emphasis was (and the same more or less continues) on creation of irrigation facilities through new projects. Not enough attention was paid to utilization of irrigation potential and optimization of the production from irrigated agriculture. This emphasis has, however, been achieved at a cost. Due to greater attention to new construction, the cream of professionals is diverted to this section, while the vital function of efficient water management which calls for efficient services to ensure quality, productivity and sustainability has been side-tracked. This has also resulted in poor linkages with Government Departments on the one hand and farmers on the other. The productivity of irrigated land has been well below the potential in most parts of the country. It is high time now that Governments, as a policy, post more efficient and experienced professionals in irrigation management jobs to deliver water with a high degree of reliability, equity, timeliness and with higher efficiency of water use.

There is a big gap between potential created under projects and its full utilization at any given point of time. While a certain gap is inevitable, much of it is avoidable. A number of measures have been taken to reduce the gap, such as extension of the canal network right upto the field, modernization of irrigation systems for prevention of water losses, raising their potential to meet increased irrigation needs, providing controls, measuring devices, canal automation etc. Command Area Development Authorities have been set up for major irrigation projects in the country. However, these measures are not enough. Much more needs to be done.

8.0 Review of Management and Operational Performance

The situation is indeed very gloomy but a proper diagnostic study must be made to find out the constraints in improving the management.

Constraints in improving water management

On critical review of management and operational performance it is found that a number of constraints being presently experienced have to be removed.

i) Physical Constraints

- Inadequate maintenance has resulted in reduced efficiency of water use and inequalities in water distribution. Of the meager funds allocated, 80% are spent on staff. The technical component is very low.

- **System inadequacies**
  Inadequate capacity of the system for timely deliveries of water to the field.

  Conjunctive use of ground and surface water is not encouraged through the mechanism of pricing and funding policies for ground water development within the command area.

  Inadequate infrastructure for quick communications and responses to ensure effective water regulation and control.

  Inadequacy of water regulation and control structures causing waste and inequitable distribution, unreliable supplies and improperly planned water distribution, apathy of farmers, excessive seepage losses.
  Lack of initiative to introduce modern and innovative methods right from reservoir to water deliveries and down to farm management, resulting in sub-optimal water management.

(ii) **Institutional Constraints**

- **Organisational inadequacies**

The irrigation departments have changed little over time. Administration is centralized, lacks accountability and corporate management skills. Unlike as in the private sector there is no prime thrust. Staff structures have a predominant mix of engineering skills with limited contribution of other related disciplines. There is not much coordination with other departments especially the agriculture department.

Very loose linkages exist between the irrigation services provided, revenues generated, expenditures incurred and staff incentives.

Involvement of the public sector has been more or less as a monopoly agency, without direct accountability to the users and unmindful of the quality and service provided and revenues generated. There is no motivation for the staff to improve the quality of service. There are no linkages with the users (farmers). Waste of water and subnormal irrigation utilization go unnoticed.

- **Limited specialization and staff skills**

Professionals are transferred frequently resulting in discontinuity in carrying forward various improvement programmes and loss of opportunity for specialization. This is largely due to lack of a firm policy on recruitment, placement and training, and recognition of outstanding services. Sub-professional and lower staff are not imparted appropriate training and lack opportunities for development of skills.

Too much political involvement in day-to-day issues of water management takes away initiative from the operating personnel and results in poor management, inequalities and lack of prompt action especially in emergency situations.

- **Divided responsibility and lack of coordination**

The subject of water is divided amongst different departments. As a result, there is no mechanism by which a final decision on competing or controversial issues can be taken within a framework of policy guidelines. Optimal use of water becomes the victim.

(iii) Financial Constraints

- Low water charges resulting in continued subsidization of O & M as well as the interest on capital.
- Incentives for efficient water use are largely absent.
- Water charges are on area irrigated rather than on a volumetric basis. This leads to wastage of water.
- Overstaffing of the management organisation resulting in high establishment costs.
- Electricity for ground water exploitation is heavily subsidized resulting in over-exploitation and mining of ground water and over-consumption of electricity due to lowering of water table and poor efficiency of the pumpsets on account of deficiencies in the pumping system, theft of energy, lowering of ground water table, increased salts in ground water etc.

9.0 Participatory Irrigation Management (PIM) and Water Users Organisations (WUOs)

There had been attempts in the 80s by different States to organise farmers' groups like Water Panchayat or Societies. However, no steps were taken to transfer the system to the users. Many of the Societies withered away. WUOs did not have legal backing. They had no resources and no authority. Recently Andhra Pradesh has taken up reform in a big way. Over 10092 WUOs have been

created in the State. AP has enacted laws. Tamil Nadu has followed suit and other States are also initiating action.

The existing Irrigation Acts do not provide for farmer participation in irrigation management. They do not provide for transfer of funds. They do not encourage mobilization of collective efforts and group initiative in irrigation management. In fact, farmers have a vital stake in water management. The designated officer of the department (Canal Officer) is vested with wide powers and he is not accountable to water users. In practice however the Canal Officer is unable to use his powers in the interest of the project due to political interference. Community involvement and participatory management imply an arrangement wherein farmers can function as equals in a participatory-cum-consultative mode. For this to happen, the Irrigation Acts would need amendment and WUO within its area of operation has to be given the power which presently is vested in state irrigation departments. WUOs require an independent resource base and an enabling institutional structure which represents various interest groups and makes WUOs accountable to farmers. The farmer's right to water (i.e. an agreed quantum) has to be recognized by law and under Rules framed thereunder. WUO should function democratically with transparency and accountability.

However, before undertaking a nation-wide programme of establishing WUOs, certain WUOs may be identified and their performance closely watched and evaluated. In the first phase, the State staff at appropriate levels should be made responsible to WUOs or should gradually be withdrawn or freedom given to WUOs to recruit their own staff. The States should, however, continue to provide technical assistance. Based on the performance of identified WUOs the institutional and legal arrangement may be reviewed and the programme carried forward under amended conditions. Continuous monitoring of WUOs through annual reports will be necessary to evaluate their performance, both physical and financial.

10.0 Conclusion

The following conclusions could be drawn:

- The country's total water requirement by the year 2050 would be between 1220 and 1680 BCM, which would be much in excess of the total utilizable average water resources of 1086 BCM.

- At the national level, it would be a very difficult task to increase availability of water for use from the 1990 level of approximately 520 BCM to the desired level of 1220 to 1680 BCM by the year 2050.

- Concentrated efforts would be required at national and regional (international) levels to harness more available waters and make them utilizable. Enormous resources and skills apart from goodwill and wholehearted cooperation from all State Governments and people would be required to achieve the same.

- The country's water resources need to be considered as a national asset and their use should be planned for optimizing benefits in the larger national interest.

- The problems of ensuring the desired availability of water are complicated by the fact that most of the undeveloped utilizable water resources are concentrated in a few river basins, for example, Brahmaputra, Ganga, Godavari, Mahanadi. Managing water requirement in space and time would be quite crucial as distribution of water resources in space and time does not match the demands.

- Greater effort should be focused on development of water of the international rivers of India for multi-purpose uses, viz. irrigation, flood control, hydropower generation, navigation etc.

11.0 Emerging Problems

The following are the emerging problems:

i Water Scarcity
ii Water Pollution
iii Water as a Major Source of Conflicts
iv Inequities in Water Supply
v Conservation and Augmentation of Water Resources
vi Inter-basin Transfer of Water
vii International Rivers
viii Reducing the Gap between Demand and Supply Water Management

11.1 Measures for saving water

Economy in water use for irrigation and other sectors is possible through various means such as:

(i) System-related means.
(ii) Technology- and science-related means - such as micro or pressure irrigation system, mulching
(iii) Economic interventions
(iv) Organizational interventions, and
(v) Other related measures.

The foregoing scenario predicted that the country will face serious challenges in water resources development and allocation. Various issues related to development, utilization and management of water resources have to be addressed in an equitable and judicious manner without jeopardizing long-term interests. This would be possible only if a national consensus is evolved on all the vital aspects relating to water, and the latest technological tools are adopted for finding solutions in an objective manner within the framework of the National Water Policy and approved master plans.

11.2 Adaption of Water Resources Management to Future Conditions

Water systems will become more and more complex and interdependent and will cover those common to adjoining countries. The benefits will be diverse with different priorities and tradeoffs. Compromises will have to be struck for finding an optimum solution within a given set of constraints. Appropriate software for real-time data input will have to be built in and updated. I can see that by 2050 or even earlier, for integrated operation, the following or similar approaches may become indispensable.

- Real-time data updated when required would have to be collected and checked at a central computer and with appropriate software. It would be processed using custom-designed software. Appropriate solutions will be sought, for flood routing or water allocation or flood or drought warning or for fixing crop irrigation or conjunctive use of water or water supply to towns/rural areas.

The main features of surface water management in the twenty-first century will most probably comprise:

- Data acquisition from satellites, weather radar, GIS and conventional telemetric systems;
- Management of the entire WR system organized in a control centre containing computers, remote data transmission systems, data banks, image processing, GIS and computer program libraries;
- Decision Support System (DSS) providing the decision-maker with management suggestions based on multi-objective compromise optima considering all relevant water quantity and water quality conditions (this decision support is based on all available information and forecasts computed with the aid of an expert system);
- Long-term effects such as climate and land-use changes computed, considering long-term decisions of WR system management.

12.0 Domestic and Industrial Water Supply

Drinking water for the community is the most vital of all demands on water and has rightly been assigned the highest priority of use under the National Water Policy. Unfortunately even after concerted efforts during the various Five-year plans, the situation with regard to the provision of drinking water and sanitation facilities in both urban and rural areas is far from satisfactory. Meanwhile the demand for water for the industrial sector is also steadily increasing. On the negative side, effluents from domestic, industrial and agricultural activities (fertilizers, pesticides, agriculture wastes) are causing pollution of water bodies. The effluents after proper treatment can, in fact, be reused for various beneficial purposes. Waste water can, thus, be looked upon as a source of additional water. This aspect would need increasing attention in future.

Here also, management issues are critical. There is considerable scope for improving efficiency. Water supply schemes should not be planned in isolation but should form part of a master plan for water development and each State should have a water policy of its own and prepare a master plan which could be implemented in the next 20-30 years. Similarly, for industrial use also, water allocation should not be made by the concerned user department but by the water authority or the nodal department for water. There is at present a multiplicity of authorities, departments and ministries to take decisions on water use. As a result, water use is being preempted in several cases without considering the priority requirements for other uses and without giving thought to alternate solutions including location of water-intensive industries in water surplus regions. In the absence of master plans for water development, inappropriate selection of water sources has caused a number of problems many of which result in sub-optimal use of water.

Water pricing requires a total review so that each user of water pays the appropriate amount in order to render the water supply schemes self-supporting. The sector which can afford more should

pay higher water charges. If there is no recovery of charges it would not be possible for long to implement the programmes for water development which ultimately would impede the development of the State and also contribute to further deterioration of water quality and environment.

13.0 Flood Control and Flood Management

The Himalayan rivers bring considerable quantities of silt and their basins are suffering drainage congestion and flooding. Similarly, deltas and estuaries of the west- and east-flowing rivers also suffer from floods. On an average, the area affected by floods annually is about 7.52 Mha of which the crop area affected is 3.52 Mha. The floods have claimed on an average 1,515 lives and 95,285 heads of cattle every year during a span of 44 years from 1953 to 1996. In spite of flood protection works such as flood embankments and flood cushions in large reservoirs, the problem of floods remains. With the growing population and increasing developmental activity and construction in the area of flood channels, the flood plains are being increasingly occupied resulting in more and more damage. The concept of flood zoning is by and large not implemented. Although it is feasible in most cases to provide a certain degree of protection against flood in terms of reduced frequency and flood damage, there are no universal solutions which can provide complete protection against floods. The country has, therefore, to shift its strategy towards efficient management of flood plains, flood proofing including disaster preparedness, response planning and flood forecasting and warning, and other non-structural measures such as disaster relief, flood fighting including public health measures and flood insurance.

14.0 Role of the Centre

Water is at present virtually a State subject. Development and management of water can no longer be considered to be the responsibility of the States alone. If development continues to take place under the existing legal and institutional framework,

the States can use about 33% of the available surface water. If development takes place under a well-defined National Water Policy considering water as a national resource, we can enhance the utilization to one half of the available water. The additional benefits from adopting a sound National Water Policy will not be limited to increased use of water. With the increase in the efficiency of use of water and diversification of cropping patterns we can enhance the benefits much more. In our country, land resources are plenty considering the global scenario. For optimizing land benefits we need more and more water.

The Government of India had prepared a conceptual national plan for development and use of the country's water resources, considering water as a national asset. The plan comprised development of (i) national rivers and (ii) international rivers. The rivers are proposed to be interlinked and all feasible storage sites to be developed optimally to enable transfer of water from water-surplus to water-deficient areas. The plan had large benefits of flood control, hydropower generation and water supply. It is now nearly 20 years since investigation and preparation of concrete projects were entrusted to the National Water Development Authority but not much headway has been made – largely because of non-cooperation of certain States and absence of a legal framework under which the Centre can undertake planning and investigation in the larger interest.

It is high time that the Central Government played a more effective and increasing role in optimal and harmonious development and efficient management of water resources at economic costs. The National Water Policy has to lay down criteria for allocation and State as well as master plans for water development must be evolved and approved at the national level in consultation with the States. The Centre has made efforts in this direction, but greater stress has to be laid on purposeful monitoring and evaluation of large projects and programmes. The reports could then be given wide publicity throughout the country. This would bring transparency and would keep the public informed about the manner in which State finances have been

mobilized and the efficiency achieved in managing the resources, and the accrual of benefits to the beneficiaries at large.

B. Water-related Disaster Management

1.0 Definition of Disaster:

There are several definitions of a Disaster; I shall, however, refer to the following definition given by Mr. Nick Carter in his book "Disaster Management – A Disaster Manager's Handbook".

"An event, natural or man-made, sudden or progressive, which impacts with such severity that the affected community has to respond by taking exceptional measures".

The same author defines Disaster Management as under.

"An applied science which seeks, by the systematic observation and analysis of Disasters, to improve measures relating to prevention, mitigation, preparedness, emergency response and recovery".

2.0 Water-related Disasters:

These may include:

1. Floods
2. Droughts
3. Dam/Embankment failures
4. Cyclones
5. Inadequate and inept handling of water management issues progressively leading to poor availability of water for various reasons.

3.0 Floods

Floods may be of long or short duration with practically no warning. The Himalayan rivers generally have long duration floods while peninsular rivers, particularly rivers having a small catchment located in stormy areas, have short duration floods with practically no warning. In the Himalayan rivers

the rate of rise of water is comparatively low while in the west-flowing rivers where the storm moves from east (Bay of Bengal) to west, the magnitude grows towards the mouth of the river and exceptionally high floods occur with exceptionally high rate of rise, say 12 ft. an hour (as in the Narmada at Garudeshwar). The Sabarmati River at Ahmedabad generates flash floods like a tidal bore moving very fast. There have been occasions when the washermen drying their clothes in the riverbed did not have time to run to the bank before they were swept away by the floods. Each river flood has its own characteristics and has to be tackled on an individual basis. The major impact of floods is inundation of land and property on the banks and sometimes riverbed, erosion of bank, damage to or washing away of structures across a river that may involve large-scale loss of life and property.

Floods and drought – a recurring feature

India is a vast country with a total geographical area of 3.29 million sq. km. Due to its vastness, diverse relief features and geographical locations, different regions of the country have varied climates and rainfall patterns. It is therefore not uncommon to find one part of the country in the grip of severe floods while another part is suffering under the effects of drought.

Many a time it so happens that even in the same year in a State, some areas have excessive rains and consequent floods while some other areas suffer due to poor rainfall and consequent drought. On the one hand, with human activities, the upper catchments denude and degrade bringing more sediments that cause greater severity of floods, and on the other hand, the rapid increase in population and consequent increase in all-round activities of man result in the flood plains being occupied to an ever increasing extent, thus causing more and more loss of life and property.

The need for flood management was felt in the early fifties and the National Flood Management Programme was launched in 1954; the area provided with flood protection was then around 3 Mha. The total length of embankments was around 6000 km.

In the initial Policy Statement made in 1954, the objective set before the nation was to rid the country of the menace of floods by containing and managing floods. However, it was realised afterwards that absolute immunity from flood damage was not physically possible even in the distant future because of the unpredictability of several events which occur along with the worsening situation caused by man-made activities. Hence, it was decided to provide reasonable protection found technically and economically justifiable and lay greater stress on flood forecasting, flood warning, flood fighting and flood management.

A number of National and State-level committees were also set up from time to time thereafter upto 1976 when the Rashtriya Barh Ayog (National Flood Commission) was constituted.

Rashtriya Barh Ayog

Rashtriya Barh Ayog was constituted by the Government of India in July 1976, under the Chairmanship of Shri Jaysukhlal Hathi.

Its main terms of reference were:

a) To review and evaluate the flood protection measures undertaken since 1954 with special reference to the construction of embankments.

b) To evolve a comprehensive approach to the problem of floods as a part of optimum and multipurpose utilization of water resources, keeping in view the role of soil

conservation and afforestation; suggest criteria for appraising flood protection schemes and mobilizing resources and therefore, make recommendations on appropriate land use in flood plains, review maintenance of flood protection works and review the existing organisation and set-ups on flood control at the Centre and State levels and suggest improvements, where necessary.

Recommendations of RBA and their follow-up

The RBA made 204 recommendations. Some of the major recommendations are described below :

- Flood Plain Zoning and its management are necessary. Very few States have prepared Flood Plain Maps showing the frequency and intensity of floods. Only Manipur has enacted a Flood Plain Zoning Act. As a result, periodic displacement and rehabilitation of large numbers of people has become a common feature and huge amounts are paid by way of compensation. A Master Plan should be drawn up for regulation of man-made activities in the Flood Plain Zones and if necessary, rehabilitation should be on a permanent basis with employment potential nearby.
- Unauthorized river bed cultivation needs to be prevented.
- For evaluating the performance of existing and future flood control works, an appropriate database should be built up.
- Flood damage may be reported basin-wise separately for
  - unprotected areas
  - protected areas
  - areas between embankments.
- A special flood-prone area programme similar to drought-prone area should be launched.

- A National Council for mitigating disaster should be formed.
- A Master Plan for flood control in a basin should form an integral part of the Master Plan for optimum utilization of land and water resources.
- Follow-up on 25 important recommendations by the Working Group for the Ninth Five-Year plan revealed that no concrete measures were taken to provide tangible physical achievements.

A National Water Policy also has laid down the strategy for Flood Control and Flood Management, such as preparation of master plans for flood control and management for each flood-prone basin, watershed management, provision of flood cushion in storage projects wherever feasible, an extensive network for flood forecasting and warning along with flood zoning. Greater emphasis has been laid on non-structural measures such as flood plain zoning, flood proofing etc. The various structural measures for controlling floods are:- 1. Dams and reservoirs 2. Detention basins 3. Embankments, floodwalls, seawalls 4. Channel Improvement and 5. Drainage improvement.

Non-Structural measures: 1. Flood plain management including zoning and regulation of building activities 2. Flood forecasting and warning 3. Disaster planning 4. Flood fighting including public health measures and 5. Flood insurance.

People's participation at all stages is a sine qua non for relief and rehabilitation measures.

4.0 Drought

The effect of drought extends over large areas, which are usually well known. It has a major impact on agriculture, livestock, rural activity and human habitation. It may lead to prolonged food shortages or famine which have a long-term effect in the form of severe economic loss and adverse impact on future development of the region and sometimes abandonment of large tracts by man,

and migration of animals in large numbers. Man-made activities may also contribute to the severity of drought, namely destruction of forests, overgrazing of agricultural and grasslands. The States have taken up a number of relief measures which, in most cases, do not prevent recurrence of droughts. The countermeasures should include long-term strategies, namely inter-basin transfer of water, development of rural areas with small-scale industries, watershed development, more efficient land management under low water availability conditions. The master plan for water resources development for a region or for a State or country should provide a minimum quantity of water for drought-prone areas by inter-basin transfer or transfer from a water surplus area. Drinking water becomes a problem for which piped water supply on a regional pipe network basis may be planned as in the case of Gujarat.

5.0 Dam/Embankment Failures

These events are rare but they do happen, causing havoc, namely loss of human and animal life and vast destruction of land and property. This is largely a man-made event except occurrence of floods in the rarest event of say 1 in 1000 or more. The preventive measures extend right from conception to commissioning and continue throughout the life of the reservoir. The investigations should be thorough and the structural designs should be safe for the foundation conditions. The hydrological studies should be data-based and realistically estimate the design flood and maximum probable flood for the project, and the spillway must be designed for safe negotiation of likely high floods. The monitoring of the health of the dam should be done continuously by visual observation as well as by the behaviour of the instruments embedded in the dam. Dam safety units have been set up by a number of States. There is a need for training and dissemination of knowledge and experience obtained worldwide so that the problems of dams in distress could be attended to in time, averting catastrophic failure.

Similarly, embankment failures may inundate large lands and cause damage to life and property. Embankments are not designed to withstand maximum floods as in the case of dams, in the interest of economy and safety. Breaching sections are provided so that they do not get overtopped except at pre-determined sections. This would limit the damage. Preventive measures include evolving a safe design, adequate maintenance, repair and vigilance during the rainy season. Embankment failures are more frequent in Bihar and UP and cause large-scale damage. Accessibility is very important so that men, materials and equipment can be mobilized to prevent the breach and if it has occurred, to close it. Protection materials such as rubble and sand bags can be stacked near vulnerable sections.

6.0 Cyclones

The areas which are prone to cyclone are generally known. Normally, we get early warning from the India Meteorological Office and systematic international meteorological observations and forecasts. The major impact is from the destructive high velocity of winds, storm surge (producing inundation), flooding from intense rainfall causing destruction and severe damage to buildings and structures, roads and amenities, essential services, crops and to the environment in general. Major loss of life and livestock may occur. Coastal towns and utilities such as ports and power stations are affected. The countermeasures include effective warning arrangements and precautionary measures taken thereafter to minimize the damage, moving people to safer shelters, public education and awareness, and limiting the damage by construction of treebelts and shelters for affected persons. Rehabilitation of people and agriculture also may be required. Transport, emergency food and medical supply, shelter materials are all required for relief and rehabilitation.

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Acronyms

CCA: culturable command area
PAPs: Project Affected Persons
NCIWRDP: National Commission on Integrated Water Resources Development Plan
km^3: Cubic kilometre
UN: United Nations
O & M: Operation & Maintenance
BCM : Billion Cubic Metres
GIS: Geographical Information System
WR: Water Resources
RBA: Rashtriya Barh Ayog

KALYAN BANERJEE

Biological Disasters and their Management

The concept of biological disaster is relatively new as compared with the disasters caused by vagaries of nature like earthquake, flood, tornado, fire, prolonged drought; or ravages of warfare including nuclear holocaust. A biological disaster can be defined as intense suffering or death on a massive scale occurring in a population and caused by biological agents. The offending agents may be microbes or toxins, acting either directly or through the mediation of vectors (carriers). It is not that massive deaths caused by microorganisms did not occur earlier; for example, plague caused periodic massive deaths all over the world, from the 5th century onward; so did smallpox, and cholera. Yellow fever caused extensive illness and death in the new world. These epidemics were caused by conditions unknown to man in those days and therefore not amenable to control. They were considered as calamities similar to earthquake or flood and in some quarters as the will of God.

About the end of the 19th century, scientists of the stature of Robert Koch and Louis Pasteur ushered in a revolution in medicine

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by elucidating the microbial basis of infectious diseases. This was rapidly extended to the understanding of the spread of these organisms and the disease processes both in man and animals. The concepts were rapidly extended to plant diseases as well. The knowledge thus gained led to the prevention strategies, like improvement of hygiene, water purification and its supply, pasteurization of milk, proper disposal of human and animal wastes, aseptic surgery, development of a number of vaccines etc. These last led to the elimination of a number of diseases like cholera, typhoid, diphtheria, whooping cough, tetanus leprosy etc., from the so-called developed world. The developing world has still to reap the harvests of these developments fully, simply because they have not yet been fully implemented. Wherever implementation is satisfactory, the benefits are apparent.

Not very many years after the beneficial revolution, the use of the microorganisms for destructive purposes was thought of. It has been reported that during World War I, serious attempts were made to attack draft animals of the enemy through microbial agents. Even earlier (18th century) an English army man spread smallpox to Red Indian tribes by gifting them blankets soiled by the scabs and pus of smallpox victims. The contagious nature of smallpox was well known to the Europeans then, while the American tribes were blissfully ignorant. [The causative agent, the small pox virus, was elucidated only in the 2nd quarter of the 20th century]. With the new knowledge of microbiology, genetic engineering, fermentation technology and genomics developed during the closing years of the 20th century, the possibility of the use of microbial agents as weapons of mass destruction is real.

As a ground reality, what are the possible causes of biological disasters in a densely populated, low per capita income, tropical country like India? There is a rickety health infrastructure, in the form of PHCs, usually undermanned, and if manned, then by apathetic officers [though there are brilliant exceptions] and mostly pressurized to carry out jobs like family planning and some curative aspects. The routine vaccination coverage can be graded at best good – fair in certain states and abysmally poor in some. Health intelligence is almost nil, in most of the places. In

recent years there has been improvement of communication through telephones, though in a large majority of places they remain out of order. Transport is still a major problem. Power cuts render the storage of routine vaccines in refrigerators difficult. Safe drinking water supply is a rare luxury in large parts of the country. Even in metropolitan cities, where water filtration plants exist, the quality of water at the consumer level is often unsatisfactory. The system of disposal of waste water and sewage is uniformly bad in most cities and non-existent in the rural areas. There are large agglomerations of urban slums, where even the least amount of health facilities do not exist. Huge numbers of people live in unbelievably overcrowded places. They do not come under the PHC scheme because they are in "urban areas". They are supposed to be looked after by the local bodies eg., the municipalities. The local bodies have neither the will, nor the capability or the finance to provide the basic amenities. However there is a silver lining. It has to be admitted that during the National Immunization Days the staff almost miraculously delivered the oral polio vaccine in good condition in most places. Except for some districts of UP and Bihar, the NIDs have been successful and have delivered the desired results. It shows that with sufficient drive, motivation and with a moderate amount of financial input improvement of the health delivery system is a distinct possibility. The question is, who is going to bell the cat? It is hoped that with the new initiatives for road-making and rural water supply, things will improve. Will the continued maintenance of roads and water supply receive appropriate funds and attention?

Therefore in India the sources of biological disasters are as follows:

1. **Naturally occurring.** Well-known but preventable diseases: [a] Water-borne like cholera [euphemistically called gastroenteritis], typhoid, Hepatitis A, Hepatitis E. Very large epidemics have been recorded in the past and continue to occur. [b] Vector-borne (often mosquito-borne) epidemics like dengue fever, chikungunya fever, Japanese encephalitis, malaria, kala-azar etc. [c] Person-to-person transmitted eg.. AIDS and other venereal diseases. [d] Air-borne like

influenza, measles, tuberculosis. They can also be transmitted through fomites [used clothes etc.]. The continued occurrence of these diseases is proof of the inadequacy of the public health system This includes knowledge, attitude, and practice of the health care providers and their success in transmitting the same to the public. It is to be noted that except for the new disease AIDS most of these diseases have been eliminated from the developed countries, and very often without the use of vaccines.

A point has to be borne in mind, that very often the public health people wish to dismiss the importance of a disease by calling it just 'endemic', not an epidemic, situation. Therefore they can relax. The problem lies in their insular textbook education. They do not realize that an endemicity is a mini – epidemic situation. The organism exists in nature, a susceptible population exists, a mode of transmission exists, only the number of cases is small in a given time due to certain conditions. It is like a smouldering fire ready to leap into flames the moment the conditions become favourable. It is absolutely imperative that biological disaster manager should not only be familiar with the naturally epidemic situations in a locality but also be thoroughly familiar with the endemic infectious diseases.The shortcomings of a public heath system must be thoroughly investigated and strengthened bearing in mind both the conditions.

2. **Emerging infectious diseases.** An emerging infectious disease can be conceived as [a] an infectious disease that is totally new to medical science, [b] an infectious disease that did not occur in a geographical area, but is now occurring, [c] a disease that has changed its nature, clinically, genetically or epidemiologically. It is beyond the scope of this paper to deal with the phenomenon of emerging infectious diseases in depth. However it would be desirable to discuss the principles in brief. The Russian Scientist E. N. Pavlovsky developed a concept of the natural nidality

[nidus = nest] of infectious diseases. It was postulated that the microorganisms exist in a natural environment that is best suited for their existence. A microorganism exists in a natural environment together with its host and its vector, if it is a vector-borne organism. The controlling factors may be geographical conditions, climate, rainfall, flora, fauna etc., which in their turn may influence the population and behaviour of the vectors or the hosts. When man intrudes into the ecosystem he is likely to be infected. If conditions become more favourable for the multiplication of the organism, vector or host, it may cause an epidemic or epizootic [epizootic = affliction of animals, cf, epidemic = affliction of humans]. An example nearer home is the Kyasanur Forest disease. In 1956 for the first time, an outbreak was reported from the Malnad area of Karnataka, with reports also of monkey deaths in the forests. The disease was investigated and named Kyasanur Forest disease and a virus was isolated. The disease affected predominantly those people who visited the forests for vocational purposes, and was characterized by sudden onset, high rise of temperature, severe prostration, body ache and hemorrhages in the skin and mucous membranes. Mortality was 10-15 per cent. It was found to be transmitted by the bite of a specific variety of tick. Further investigations revealed that the outbreak which persisted year after year was due to the increase in the tick population and conditions made favorable for the transmission of the virus from monkeys to man. It was due to the ecological challenges brought about by human activities. The virus is highly infectious as such, and the WHO has classified it as one which needs the highest level of biosafety laboratory to handle.

Yellow fever is an example of a virus which had been transported to the Americas from its original habitat, West Africa. In the African continent it was transmitted to man and monkeys through the monkeys *Aedes Africanus* and *Aedes aegypti* respectively. In the Americas the virus found a new mosquito as its vector

together with *A. aegypti*. The latter was responsible for producing massive epidemics of yellow fever in south, central and north America in the 19th and the earlier part of the 20th century. However improvement of public health, vector control measures, and the yellow fever vaccine have controlled the disease in most of the places, though it continues to linger in the forested and rural areas of South America. Yellow fever continues in West Africa. In recent years yellow fever has crossed to East Africa and this makes India a potential target for yellow fever. The vector mosquito *A. aegypti* is abundant in almost all towns and cities of India Recently it has been found to have made inroads into the villages as well. Dengue and chikungunya fevers are also transmitted by the same mosquito.

Massive epidemics due to the dengue virus have occurred in most of the metropolitan cities of India. During the epidemics of dengue fever in Delhi in 1983 and 1994-95, several million cases had occurred. The chaos and confusion prevailing during the epidemics had to be seen to be believed. During the massive epidemics of dengue and chikungunya fevers in the east coast of South India in 1965 it was estimated that nearly 30 per cent of the population became ill during a period of 40-50 days. In recent years dengue fever has assumed a new and more sinister appearance, a significantly large number of cases develop haemorrhagic manifestations and shock with considerable mortality. Cases have been diagnosed with encephalitic symptoms in recent years. This is truly an example of an emerging disease, though known for more then 200 years.

In recent years the west Nile virus (a virus transmitted by mosquitoes which were inhabitants of Africa & Asia) has crossed the Atlantic ocean to reach the USA, and has caused considerable concern.

Among the viral diseases, influenza is perpetually evolving. Usually it is dismissed as 'flu' and no serious notice is taken. However the nature of the virus is such that it can change its genetic properties by mutation and recombination. Though most people

have antibodies against the more benign varieties of flu. occasionally a new virus emerges, which can produce devastating epidemics or pandemics [global epidemic]. The pandemics of influenza in 1918, 1957 produced massive morbidity and mortality all over the world. In 1997 a new recombinant strain of influenza virus lethal to man was found in Hong Kong, which was a recombinant between human influenza virus and a bird influenza virus. It was suspected that chicken imported from the mainland were harbouring the new virus. Millions of chicken were culled to curtail the epidemic.

New viruses like HIV 1 and 2 have emerged probably from inapparent viruses of human or primate origin or some still unknown mechanism in nature and have caused extensive epidemics all over the world. In certain countries of Africa massive mortality due to HIV virus has caused alteration of the demographic picture. It is still anybody's guess whether the drug-resistant HIV viruses will create new epidemiological problems.

Viruses like Hendra or Nipah which were probably of animal origin crossed the species barrier and caused human epidemics.

New strains of cholera have caused much morbidity in many places of the world. New strains of E. coli (a relatively common microorganism) now producing intestinal haemorrhages and severe diarrhoea have been of much concern all over the world. The rampant use of antibiotics has caused the emergence of drug-resistant typhoid bacilli and common organisms like strepto and staphylococci all over the world. The plague bacillus which had produced massive epidemics all over the world still lurks in certain foci producing a few human cases, in China, the USA, Madagascar, and Vietnam and may emerge as a problem.

The multidrug-resistant tuberculosis bacillus is emerging as a major problem all over the world

3. Man-made biological disasters

Biological warfare and Bioterrorism

It has been mentioned earlier that soon after the knowledge of microorganisms came into being their use was contemplated in warfare. However the concept is much older. In fact the use of birds, owls, bats, mongooses etc. to carry incendiary materials into the forts of the enemy, has been mentioned in Kautilya's Arthashastra. Kautilya has been very careful to warn that such methods are to be used as a last resort, for they can cause unwarranted damage to the user party as well. But it is correct to assume that real and conscious use of biological material (principally microbiological) as a practical method of warfare came into being in the 20th century. In the 21st century, the spectre of biological warfare is real and looms large.

In the history of warfare paradigm shifts in strategy and technology of warfare have resulted in massive victories in favour of parties or nations who adopted them at the appropriate time. There are many examples to prove the above theory. It is becoming more apparent that in a unipolar world [at least for the next 10-20 years] wars will be of short duration, clad in secrecy, stealth and surprise. Biological warfare represents a paradigm shift and fulfils the above requirements very well.

Of all the weapons of mass destruction [conventional, chemical, nuclear and biological] the biological weapons are to be most feared [JAMA 1997; 278, 431], and not only as weapons of mass destruction. Biological weapons can be adapted and used as weapons of attrition. They are more esoteric, more varied, and subtle. The threat is truly global [irrespective of polarity]. The volatility of the world political environment has lowered the threshold and increased the potential use of these weapons.

In a way, biological weapons are different from other weapons. A chemical may kill an animal and that is the end of it. A bomb may explode and kill a number of persons, and that is the end of it. A biological weapon consisting of an infectious microorganism will enter the body of a man or animal, multiply in the host and then infect a further crop of animals or people. There is a cascade of self-propagating infections, and within a short time a very large

number of hosts can get infected from a singly source. Manufacturing bioweapons requires no large facilities [like nuclear or conventional weaponry]. Their immense variability makes them difficult to diagnose. Any outbreak due to an unknown or exotic organism easily gives rise to public panic, media hysteria and disruption of normal civil activity. They can be tailored to resemble natural disease conditions. Needless to say, several naturally occurring microorganisms [eg., smallpox anthrax, Venezuelan equine encephalitis, plague etc.] can be used against a susceptible population as biowarfare agents. Depending on the intent and nature of the micro-organisms, they can be spread in the community through aerosol or through contamination of water supply or even through a cold bomb exploding at a height forming a cloud of infectious material. Toxins may be used [eg., botulism toxin] to contaminate water supply. However, modern molecular biology can give rise to an infinite variety of modified microorganisms or toxins; they may be ethno-specific, mood-changers, or even immune evaders, so that the body immune system or pre-existing antibodies cannot prevent their damaging effects. Even if we think of these as weapons of the future, there are enough numbers of naturally occurring microorganisms and toxins and they can easily be grown in fermentors and used as weapons of biowarfare or birterrorism.

The history of bio-weapons can be traced to the use of the smallpox virus for the decimation of Red Indian tribes in North-America. Several belligerent nations during the World War II had bio-weapons programme. Of these the Japanese programme was the most aggressive and was actually used in China causing considerable mortality and morbidity. However it was terminated with the end of the war. The data generated by the Japanese biowarfare scientists were handed over to the forces of the United States, when they occupied Japan. The other nations, principally the USA, UK and USSR continued their programmes till 1972 when the Biological and Toxin Weapons Convention (BWC) was opened for signature and eventually ratified by 140 nations.

During the 1960s, the heyday of nuclear technology, biological warfare was considered of the low importance and President Nixon declared the stoppage of the BW programme in the USA. However despite the BWC the USSR continued its programme, a fact which become apparent after the collapse of the USSR. Only glimpses of the US programme are available in the literature. However in the late 1990s President Clinton of USA made a large allocation of funds for the bio-defense programme. The Bush administration continues to support it with a few billion dollars. It is true the BWC has been ratified by 140 State parties, but it has several loopholes. [1] The BWC is binding only on the governments or State parties, it is not binding on their citizens per se (US Senate 101st congress 1st session report 101-210 p4, 1989). It is therefore necessary for the State Parties [according to Article IV of the BWC] to pass domestic legislation which would make the development, production, acquisition and stockpiling of biological and toxin weapons acts of crime and punishable by law. It is also necessary to pass national legislation preventing unauthorized and criminal access to such agents and terrorist use of them. It seems that such laws have been passed by only a few countries (Scott D. in 'Prevention of a biological and Toxins arms race and the responsibility of scientists" eds. Geissler E and Haynes RH. pp 345-67 Academie Verlag; Berlin 1991]. For the benefit of India it is absolutely necessary to know whether such laws exist for India and its neighbouring States particularly Pakistan, Nepal, Bhutan, Afghanistan, Myanmar, China, Iran, Iraq and other Arab countries. [2] The BWC does not limit research on biological and toxin weapon agents. This unrestricted freedom of research with potential BW agents can be utilized by potentially aggressive parties. Research facilities can be used to conceal prohibited activities such as development and production of BW material at least in limited amounts if not for mass destruction but sufficient for terrorist activities. There is no guideline provided within the BWC regarding the quantity of a particular agent that can be considered permissible for research purposes or permissible for therapeutic purposes beyond which the material should be banned, Research might also lead to the construction and development of new types of agents [toxins]

which might be very potent so that even a small laboratory-scale preparation might be enough to produce the desired damage and would be enough for military use. The recent development of biotechnology has resulted in the invention of rapid methods of production which make stockpiling of BW agents unnecessary. [3] The BWC permits the development, production and stockpiling of BW and Toxin weapons [TW] for prophylactic, protective and other 'peaceful' purposes without limitation including activities ostensibly carried out for these purposes. Even these 'permissible' and 'defensive' activities may require the handling of highly pathogenic matter and extremely potent toxins. Work with such material poses a threat to the personnel involved and to the public. In the highly developed countries it is estimated that 5 infections take place per year per 500 persons involved [Israeli E. Adv. Biotechnological Processes; vol 6, pp 1-30, 1986]. Needless to say it is likely to be very high in less developed countries for this type of work. Apart from other factors this reason alone is of serious concern in the proliferation of biotechnology as related to BW and TW material (Rosenberg B. Document: US Dept. of the Army; US Army Medical Research and Development Command. Fort Detrick, MD Apr 1989, Pp A14-50 – A14.55). It must be emphasized that if Research and Development is carried out with pathogenic agents capable of being used in the BW or TW field [even though the research is not sought or intended for military purposes] under conditions of insufficient technical competence and responsibility, a breakdown of containment would occur resulting in outbreaks of epidemics. It is not always necessary that the outbreak would start from the staff of the laboratory or within the vicinity of the laboratory. [4] A very desirable activity like the development of a vaccine against a pathogenic agent can be used for a quite different purpose if given a military bias. It may be used for protecting research workers engaged in offensive R&D programmes as well as troops in advance of an intended attack using a certain BW or TW agent. Vaccination can therefore give a first strike capability especially if the vaccine is intended to protect against a variant agent which has simultaneously been constructed as part of a clandestine and prohibited activity.

However it must be borne in mind that vaccines need to be developed and the troops vaccinated against pathogenic agents present endemically or causing natural epidemics in areas where the troops are likely to be active. For example, the US army vaccinated its troops against Japanese encephalitis virus for their protection in Japan and other South-East Asian countries. It is therefore important to know in advance the diseases or the prevalence of pathogenic agents in places where the troops of a country are going to be active. This is a legitimate activity under the BWC.

The weakest link in the BWC is verification. It is beset with many problems. However it is not the purpose of this paper to discuss these, the methods of strengthening the BWC, the confidence building measures etc.

India and bioterrorism

India is a signatory to the 1972 BWC. It is in the fitness of things and in keeping with our tradition that India should never venture into the development of offensive bio-weapons. It must cooperate with other nations in curbing such activities. However, it remains a sitting duck for any bioterrorist attack. Health intelligence is abysmally poor in India. There is really no mechanism to deal with a public health emergency or to allay panic among the people in such an eventuality. Nor is there any mechanism for diagnosing the causative agent in a short span of time so that adequate preventive measures can be introduced against the spread of the disease.

As the first few cases after a BW attack will appear in the emergency offices of hospitals, it is imperative for the junior doctors or residents [who normally man such admissions] to recognize that something is amiss and something new has come in. This necessitates a thorough revision of the medical curriculum laying stress on infectious diseases and their diagnosis. Sadly at present the medical colleges in India place very little stress on the teaching of infectious diseases. Next comes the role of

virologists, microbiologists or toxicologists to diagnose the pathogenic agent as early as possible. The collection of appropriate samples from specimens and their preservation and transport in good condition to the laboratory for diagnosis are equally important. This requires extensive training of personnel. A single central laboratory or a couple of laboratories for the diagnosis of all outbreaks will lead only to chaos, mismanagement, and misdiagnosis. A chain of diagnostic laboratories should be built all over the country. They should have the capability to diagnose a number of disease conditions, while each should have the capability to deal with a few specialized and difficult conditions. These laboratories should work in close cooperation among themselves. With close cooperation between clinicians and laboratory scientists these laboratories should be able to diagnose the oft-occurring infectious diseases, emergent diseases and also the agents employed for any bioterrorist attack. The important thing is that all health personnel including the laboratory workers should be aware of and in touch with the process of investigation of infectious diseases, their outbreak and the sources, and try to eliminate the weaknesses in the public health chain. It is for this reason that knowledge and investigation of endemic diseases as well as epidemic diseases are important.

The consequence of a biological attack is an epidemic. It has been mentioned earlier that in an economy dependent upon agriculture as in India, attack on an animal wealth causing an epizootic [diseases like rinderpest and foot and mouth disease in cattle, African horse sickness in horses are a few examples] can also be very damaging. Needless to say an attack on main agricultural food crops like wheat, rice, jowar, and cash crops like cotton and sugarcane can render a crippling blow to the nation. A country carrying out monoculture of wheat, rice, maize, jowar, is specially vulnerable. It should be borne in mind that some of the superpowers had massive stocks of fungal spores capable of infecting every wheat or rice plant on this planet. In recent years the harvest from the oceans is also an important source of food and revenue to nations. Food originating from the oceans is likely to be more important in future than it is now.

People involved in biowarfare may create problems in this territory as well. Therefore, the ability to diagnose the causative organism of an epidemic or epizootic or outbreak of disease in plants, is the first important condition to handle an outbreak. As has been mentioned for the epidemic situation [disease in humans] diagnostic facilities should be available for rapid diagnosis and dissemination of information. This necessitates the existence of an infrastructure by which the states could develop an integrated surveillance system for diseases. As in every case, prevention is better than cure and the development of a competent surveillance system would help the country minimize the risks and damage which can be inflicted by epidemics either natural or man-made. For agricultural bioterrorism, it is not only the bioterrorrist who should be looked for, but commercial interest [particularly in these days of seed monopoly] should also be closely watched.

Notwithstanding the importance of animal or plant diseases and the possible damages that can be caused to the nation through biowarfare or bioterrorist attacks, constraints of space and time force us to restrict our attention to a few current problems of human affliction. It is beyond the scope of the present paper to deal with the different microorganisms and toxins capable of being used as bio-weapons.

Smallpox. Smallpox is caused by a virus known as variola. It had produced extensive epidemics with heavy mortality. Under the leadership of the WHO the world community eradicated smallpox from the world and since 1977 vaccination was discontinued throughout the world. However some countries continued vaccinating their troops after the eradication campaign was successfully completed the world community destroyed all samples containing variola virus, except those, which according to the WHO fiat were stored in two places, one in the USA and the other in the erstwhile USSR, now Russia. The vaccine produced against smallpox was not derived from the variola virus but from cowpox virus. With the discontinuation of vaccination and the absence of natural smallpox, the world community is totally devoid of immunity against smallpox. Therefore the variola virus

has now emerged as a potentially successful weapon for biological warfare. It is now acknowledged that the USSR did weaponize variola virus though clandestinely. It is now argued that terrorists might acquire variola virus, and therefore research must be carried out for the development of a better vaccine and drugs to be used against variola infection particularly for HIV-infected persons. Needless to say, these are mere apologies to take out variola virus from the frozen stocks. The USA has spent nearly half a billion dollars for the production of smallpox vaccine. It was the classical smallpox vaccine made of the original vaccine virus and not the newfangled vaccine they professed to be developing and carrying out research on. The Bush administration has recommended and started to implement vaccination for one million persons with the classical vaccine. It is understood that the Russians are on the vaccination path. It does not require a genius to understand the implications. If a smallpox attack takes place in any part of the world, it is going to be a major catastrophe. The September 11, 2001 attack on WTO will appear as baby talk. What are we supposed to do? Some of the answers are warped in international diplomacy but a few practical suggestions are:

[a] Revival of those vaccine laboratories that were making small pox vaccine during the smallpox eradication era.

[b] Stockpiling the vaccine. (Even though it is the old vaccine which has been denounced by the Americans and the Russians, we must remember that despite its few shortcomings, it is the same vaccine which was responsible for the eradication of the smallpox virus from the world.)

[c] Development of an emergency vaccination strategy. It should not be difficult, for we did develop a successful strategy for the polio vaccine and National Immunization Days.

[d] A concentrated international campaign for the destruction of the smallpox virsus stocks from the world as early as possible.

Anthrax

Anthrax is one of the earliest organisms to be isolated and has been a favorite organism for bio-weaponizers. It is a common organism found in nature. It produces anthracosis in cattle and sometimes in man. It is a very hardy bacillus and produces spores very rapidly in the presence of oxygen. The spores are very long-lived and are quite heat- and climate-resistant. Anthrax can be produced in bulk very easily in ordinary fermentors. The spores can be easily aerosolized. The aerosolized organism when inhaled in sufficient numbers can produce fatal pneumonia and rapid death. However the natural disease is easily treated by antibiotics. The USSR had a massive programme of weapon zing anthrax. A technical fault in the production facility at Novosibirsk, Siberia, let the organism out of the production facility and produced nearly 200 cases of inhalation anthrax and death in a large majority of them. After the Gulf War the UNSCOM has alleged the weaponization of anthrax by Iraq. However the recent anthrax cases caused by 'white powder' in envelopes in different parts of the USA, were truly due to the anthrax bacillus. Molecular biological studies traced the organism to certain defense establishments in the USA. The British also carried out experiments with anthrax in a remote island north of Scotland. Needless to say, the superpowers were vying with each other in the development of weapons with anthrax and it is possible that some other nations are already close on their heels. A terrorist attack with anthrax is a distinct possibility. Though a vaccine exists against anthrax for veterinary use, none is available in India for human use. Surveillance, vigilance, rapid diagnosis, and immediate use of antibiotics are the only methods to combat inhalation anthrax. Immune sera can be stockpiled for administration.

The other organisms high in the list of bioweapons are Francicella tularenses, producing tularemia [a naturally occurring disease in East Europe] and of course Yersinia pestis, the organism causing plague. Both these organisms can be grown in bulk and aerosolized for use as a bioweapon.

Drug-resistant E. coli producing hemorrhagic entericolitis or other drug-resistant bacteria can be used as water pollutants.

In 1981 about 300.000, persons in Cuba developed dengue haemorrhagic fever with considerable mortality. The whole episode lasted only a few weeks. It has been alleged that the CIA manipulated the occurrence of the outbreak. This was hotly deneid by the USA. It would be difficult to pinpoint bioterrorism in such cases. However, pinpointing a terrorist is not going to solve the suffering of the people. The solution lies again, in surveillance, vigilance, rapid diagnosis, and rapid implementation of mosquito control measures.

That a strong public health infrastructure is the single most important preventive and combative agency against naturally occurring epidemics, epizootics, biowarfare and bioterrorism cannot to overemphasized. The strongest defence against any large outbreak of disease either natural or man-made must be at the local level. There is no agency or laboratory in India (or in any part of the world) which can handle a massive epidemic. It is absolutely essential that certain central research laboratories be prepared to find preventive and curative measures or develop vaccines, but results are not likely to be available at short notice. It requires many years of painstaking research to find a solution. And when a solution is available, we need an army of trained doctors and nurses to translate the knowledge to help the patients. It may be noted that the highest research funding in USA in 2002 in the health field is against bioterrorism.

During an outbreak, the first and most important thing to do is to find the causative organism. However it is neither possible nor desirable to attempt to determine the causative organism in every case of an epidemic. No doubt the laboratory diagnosis of the causative organism will be of immense help to plan the further prevention of spread and treatment. When the disease is new, it would be necessary to develop a case definition, which would constitute a benchmark of the disease. Such a case definition should be widely circulated to all health personnel and the public

at large so that they can diagnose the condition, treat it and notify the authorities.

The greatest problem the administration encounters during an outbreak is social disorganization and panic. To combat this, social and civil values need to be strengthened. It has been seen repeatedly in many countries, that during the early phases of an unknown disease, there is considerable social disruption, mainly due to the unwarranted fear of the disease, stigmatization of individuals who have been infected and suspicion of others. However, these effects become less and less severe as communities develop strategies to cope up with the reality. Therefore development of effective communicative strategies in the early phase of the outbreak and substantial planning are necessary in advance of an incident.

During a massive outbreak, even in developed countries, the medical needs exceed the resources. In our country this is certainly true in all cases. It is natural for people to rush to a hospital when a person is suddenly taken ill. This is certainly true in the cities. Under a bioweapon attack, or during a sudden epidemic of massive proportions, the hospital services are certain to collapse. It would immediately give rise to frayed tempers leading to chaos. Arrangements for patient care, their transport, treatment, nursing, patient's food, waste disposal, disposal of dead bodies, essential services, eg., electricity, water supply, road and railway transport, public safety, law and order have to be maintained. It is quite possible that some of the workers may just run away to assumed safety. Under such circumstances, it is absolutely necessary that the public should not remain by-standers, rather they should be activily taken as partners of the services to be provided. To achieve a state of public cooperation with the administration, public health services, hospital services and the non-governmental organizations, sustained efforts are necessary for inter-sectoral confidence building and cooperation.

It is true that at present, medical curricula in the Indian medical colleges, do not emphasize such a cooperative method for

treatment of medical disasters. Our hospitals and doctors are magnificently unprepared to handle a biological disaster. The majority of doctors in Government or private hospitals have not seen, nor can they diagnose, a case of smallpox or anthrax or plague. In their curricula they are not even taught about infectious diseases in depth. It is high time that the concept of aping the western medical curricula and feeling smug about it, is put aside, and some ground realities are brought in.

The most important factor which needs to be addressed during an outbreak, is panic. Both the print and electronic media can do immense damage. During the so-called "plague" epidemic in 1994 at Surat, the media played up mass hysteria, which resulted in international ostracization of India and a loss of two billion dollars in foreign exchange. All that due to only 46 deaths the cause of which was not even properly established. It is essential to have regular briefing of the press and the media with correct information on the situation and how and what to do during the outbreak.

The recent epidemic of severe acute respiratory syndrome (SARS) is an example where panic reaction has been global, and probably fuelled by the WHO itself. Notwithstanding a few cases in Toronto and Hong Kong, there was little justification for panic reaction in India. It is true that it is really an "emerged disease". The virus genome is totally different from any virus of the family to which it belongs.

To summarize : [1] though epidemics, epizootics, emerging diseases and germ warfare as concepts have been known for quite some time, today, the threats due to natural or man-made pathogenic organisms are real. Depending upon the nature of the organism, massive damage to humans, animals or crops can take place. BW may be considered as a new paradigm of warfare, the ramifications of which are yet to be realized fully, [2] The nation should be oriented in its mindset and physically to face the problems. The following steps are imperative : (a) close interaction between the administration, health care and public health systems, and the public, (b) strengthening of the public health system (c)

development of rapid diagnostic capability for infectious diseases (d) development of a strong surveillance and health intelligence system all over the country, (e) manufacture and stockpiling of relevant vaccines, and development and sustenance of a system for their rapid delivery (f) research and development to combat newer agents.

K MURALIDHAR

An Overview Of The Emergency Response Plans In The Department Of Atomic Energy

1. In accordance with the Crisis Management Plan circulated by the Cabinet Secretariat in June 1987 (updated in August 1989), the Department of Atomic Energy (DAE) has been identified as the nodal authority in respect of man-made radiological emergencies in the public domain.

2. For this purpose, a Crisis Management Group (CMG) has been functioning since 1987 in DAE. This Group is chaired by the Additional Secretary, DAE and has Members from the Atomic Energy Regulatory Board (AERB), Nuclear Power Corporation of India Ltd. (NPCIL), Bhabha Atomic Research Centre (BARC), Heavy Water Board (HWB), Directorate of Purchase and Stores (DP&S), Bharat Sanchar Nigam Ltd. (BSNL), and the DAE Secretariat. Each Member has an Alternate Member and the CMG is backed by Resource Agencies from BARC. These Resource Agencies are expected to provide advice and assistance in the areas of radiation measurement and protection and medical assistance to radiation-affected personnel.

K. Muralidhar, Head, Mgmt. Service Group / Secretary, Atomic Energy Communication & Member Secretary, CMG.

3. The overall system takes into consideration the statutory requirements, the *executive decisions as well as International obligations*. The broad plan is that, *in the event of any radiological emergency in the public domain* the CMG is immediately activated and will co-ordinate between the local authority in the affected area and the National Crisis Management Committee (NCMC) at the Cabinet Secretariat, which is chaired by the Cabinet Secretary. In accordance with the action plan of the NCMC, the Secretary, DAE is co-opted as one of its members, in the event of a nuclear emergency in the public domain.

4. Each nuclear power station facility has an Exclusion Zone of 1.6 km surrounding the power station in which no habitation is permitted. The entire area is fenced or walled off and defines the boundary of the site. Beyond this is the public domain and an area of 16 km radius around the plant site is called the Off Site Emergency Planning Zone (EPZ).

5. As a general practice, elaborate and comprehensive safety systems are in place for the operation of any nuclear facility. These are in turn overseen by the AERB who have powers to license and even shut down any facility which violates their guidelines. However, as a matter of abundant caution, even some "beyond design basis' accidents are postulated for the nuclear power stations. *It is only under such highly unlikely scenarios, that there is a possibility of radiological emergency in the public domain.* Therefore, in addition to the other types of emergency response plans in place within the facility to handle local emergencies, response plans have also been drawn up for handling such emergencies in the public domain, which are called "Off Site Emergencies". These plans - *drawn up separately in detail for each site* - which are under the jurisdiction of the local District Administration, cover an area of about 16 km radius around the plant or the Off Site Emergency Planning Zone.

6. The first three types of emergencies which are foreseen and for which detailed plant-specific emergency response plans are made, are Emergency Standby, Personnel Emergency

and Plant Emergency. In all these, the consequences of the accident are expected to be limited to the plant facility only The next type of Emergency, which is foreseen is the *Site Emergency, wherein the consequences of an accident are not expected to cross the site boundary, that is, the Exclusion Zone - which means that even under this condition, there is no radiological emergency in the public domain.* The last type of Emergency, which assumes the highly unlikely possibility of radiological releases in the public domain, is the "Off Site Emergency" and detailed response plans have been drawn up even for this hypothetical scenario at each site. *The local District Administration, the Crisis Management Group, DAE and the National Crisis Management Committee (NCMC) at the Cabinet Secretariat, are expected to get involved only in this last type of Emergency.*

7. It is mandatory for NPCIL to have comprehensive and well laid out plans to deal with the above types of Emergencies. Barring the last one, all the others fall within the domain of responsibility of NPCIL, and the AERB as the Regulatory Authority, approves these plans. *It is also mandatory for the NPCIL to periodically test out these plans by way of exercises and drills, and take corrective measures as stipulated by the Safety Committees and AERB. As the first stage of the trigger mechanism, the Crisis Management Group, DAE and the Resource Agencies are automatically alerted even when a Plant or Site Emergency / Exercise takes place.*

8. In accordance with statutory requirements, it is the local District Administration which is responsible for drawing up and testing the Off Site Emergency Plans. NPCIL has co-ordinated with all concerned District Administrations to enable them to draw up comprehensive Off Site Emergency Plans for each power station. *It may be mentioned that the AERB does not permit any nuclear power station to be commissioned unless and until such plans for all types of Emergencies are in place well before the commissioning date.*

9. The Off Site Emergency Plans are also periodically tested, and all power stations have ensured that this *is* being done at least once in about two years. *During these exercises, all the Members and Alternate Members of the Crisis Management Group, DAE and Key DAE Officials in Mumbai are alerted. In addition, Secretary (Security), Cabinet Secretariat who is the contact point for DAE with the NCMC and the Secretary, Ministry of Environment and Forests, are also kept alerted during the Off Site Emergency Exercises.* In these Exercises, the District Administration is fully involved, and the reports of the independent observers (from AERB, NPCIL and CMG) are used as a feedback to further improve the Emergency Response System.

10. Recognising the importance of communications in the handling of any Emergency, an Emergency Control Room (ECR) is maintained at the DAE Secretariat, Mumbai. *This is manned and operated round-the-clock and on all days of the year.* It maintains continuous contact with all the critical facilities of DAE. The DAB-ECR is *backed by another communications facility of the NPCIL - which is also manned on a round-the-clock basis throughout the year - at a different location* (VS Bhavan, Trombay, Mumbai). The DAE-ECR is equipped with wireless, telephone, facsimile, VSAT and Electronic Mail facilities. These are tested practically on a daily basis to ensure their continuous availability. Further, each of the major sites also carries out fortnightly or monthly communication exercises to test all the links in the entire communication chain. The DAE-ECR also has an adjoining Conference Room facility for the CMG, DAE to meet at any time. The DAE-ECR tests its communication contacts with all the Key Officials in Mumbai, Members and Alternate members of the CMG, and the Resource Agencies, on a weekly basis and in addition keeps in regular contact with them to keep them informed about the messages / exercises from various sites.

11. In addition to about 165 communication exercises, nearly 110 emergency exercises are carried out every year. As of date, 37 Off Site Emergency Exercises have been conducted since 1987 by the respective district administrations at various locations in the country. *These involve direct participation by local district officials like police, health, transport, etc. At the end of each of these exercises the District Collector / Magistrate chairs a "critique or feedback" session at which the deficiencies are recorded for taking corrective action.*

12. The other type of radiological emergency envisaged in the public domain is that occurring during the transport of radioactive material. Mandatory design specifications for the packaging, systems and procedures for handling and transport are in place, to ensure that there is no release of radioactivity in the public domain in the unlikely event of such an accident. However, even if such an event were to occur, the procedures are such that the Emergency Control Room at the DAE Secretariat gets an alert, which in turn would immediately activate the Crisis Management Group, DAE and the Resource Agencies.

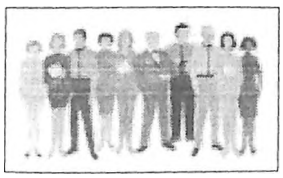
13. In the event of any other type of nuclear emergency in the public domain arising from the unauthorized presence or suspected presence of nuclear materials, a booklet giving the essential guidelines to be followed has been circulated to State Governments and Union Territories. Among other steps, the guidelines require that the nearest listed DAE facility as well as the DAE Emergency Control Room be contacted immediately. They would alert the Key Officials in Mumbai, certain CMG officials, and the Resource Agencies. The public officials at the affected site would then be advised on the necessary steps to be taken to attend to the emergency.

14. As a means of creating better public awareness on this subject, a short summary of this writeup along with some simple "Do's and Don'ts" during a nuclear emergency, have been posted on the DAE web page (www.dae.gov.in)

Presentation Structure

- About the Department of Atomic Energy.
- About Exposure to Radiation; What is a Nuclear / Radiation Emergency?
- Various ways in which a N/R Emergency could occur.
- Emergency Response Plans at national level - Role of DAE as a nodal Department during a N/R Emergency.
- Some Statutory / International issues w.r.t. N/R emergencies.
- DAE's Response System - Basic Concepts / Principles.
- Agencies involved and Resources which can be accessed.
- Responding to different types of N/R Emergencies.
- Maintenance of DAE's ERS - Formal Procedures, Communications and Periodic Exercises.
- A short recap / Concluding Remarks.

Growth of the Indian Atomic Energy Program
Manpower and Financial Resources Deployed



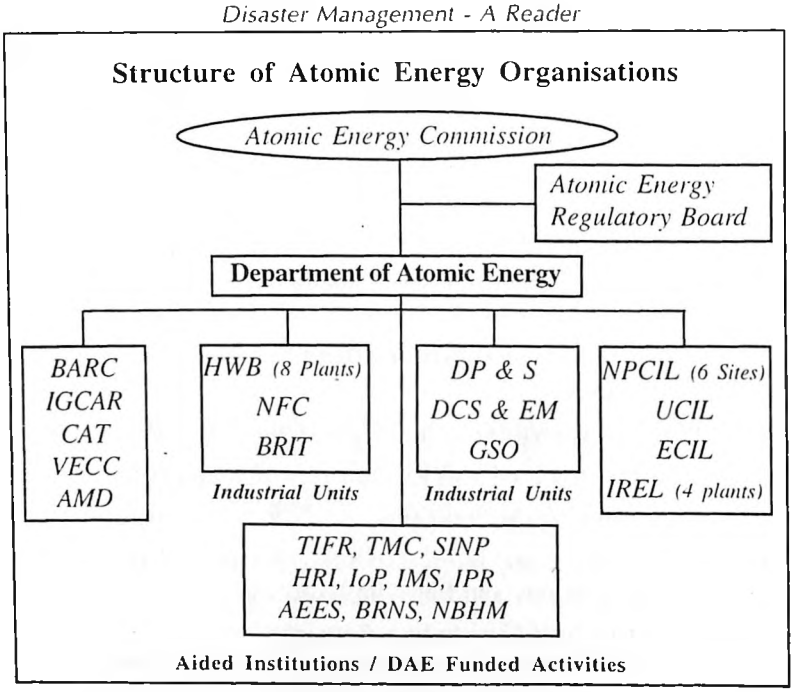
Growth of Manpower

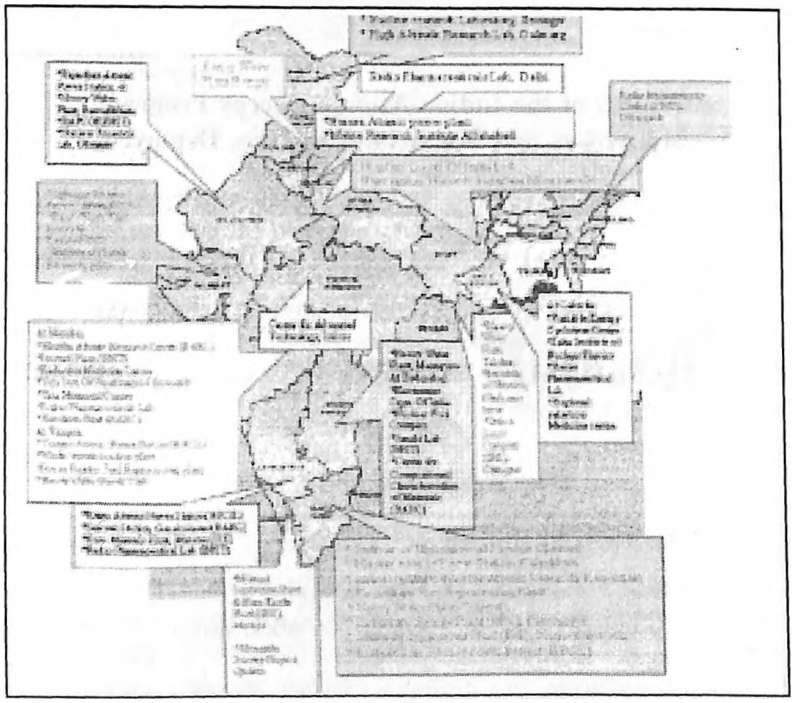
1948 - 50
2002 Estimate - About 60,000

(35000 in Departmental Units & 25000 in PSUs)

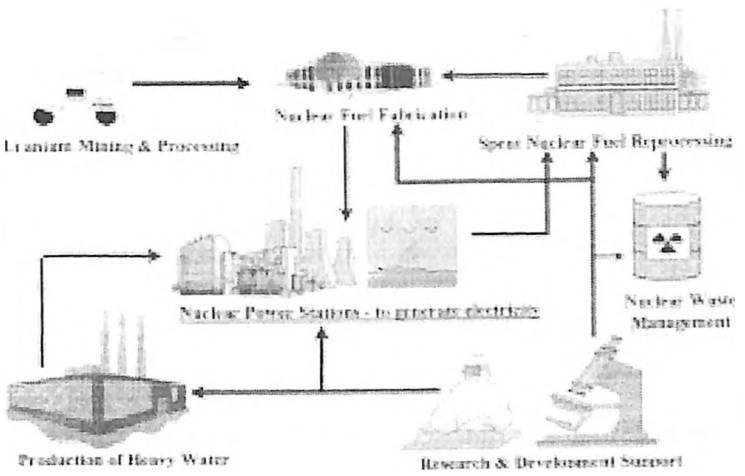
Growth in Budget

1948 - Rs. 70 lakh
2002 - Over Rs. 6000 crore


Structure of Atomic Energy Organisations
Atomic Energy Commission
Atomic Energy Regulatory Board
Department of Atomic Energy
BARC
IGCAR
CAT
VECC
AMD
HWB (8 Plants)
NFC
BRIT
Industrial Units
DP & S
DCS & EM
GSO
Industrial Units
NPCIL (6 Sites)
UCIL
ECIL
IREL (4 plants)
TIFR, TMC, SINP
HRI, IoP, IMS, IPR
AEES, BRNS, NBHM
Aided Institutions / DAE Funded Activities



Indian Technological Capability over the Nuclear Fuel Cycle



The Department of Atomic Energy has been identified as the nodal agency to render technical expertise to respond to any Nuclear/Radiation Emergency in the country - whether caused by an internal or external event.

Exposure to Radiation and its effects - Getting the Perspective Right

Due to lack of information, the general public has (rightly so) several misconceptions pertaining to radiation and its effects.
The following few slides are intended to present the proper perspective w. r. t. Nuclear / Radiation Emergencies.

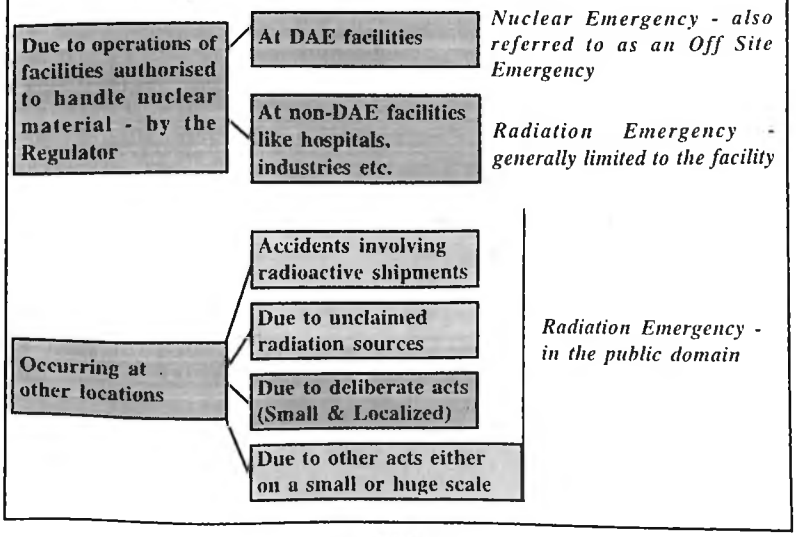
What is a Nuclear / Radiation Emergency ?

- A Nuclear or Radiation Emergency is a situation in which one or more individuals have been exposed to / or have the potential to be exposed to radiation levels higher than what is stipulated by the National Regulatory Authority. The individual could be an occupational worker or a member of the public.
- A Nuclear Emergency refers to such a situation arising due to the operations of a major nuclear facility like a nuclear power station.
- A Radiation Emergency refers to such a situation arising due to the operations of non-nuclear facilities using radioactive materials, such as, industries, hospitals, educational institutions or during the transport of nuclear material.

How can a N/R Emergency take place?

- Nuclear / Radioactive Materials - Who and Where?
- How are they controlled - their handling, usage, storage, movement, accounting, etc ?
- What are the possible ways in which a N/R Emergency could occur?

Types of Nuclear / Radiation Emergencies that could possibly occur in the public domain



Emergency Response Plans at national level
Role of DAE as a nodal Department during a Nuclear / Radiation Emergency

- National level committee / nodal ministry.
- Recent developments – Ministry of Home Affairs – first responder.
- DAE – nodal/technical expertise in the event of any N/R emergency in the public domain.
- Expertise in – radiation measurement, protection, medical response to radiation injuries.

Some Statutory / International Issues w.r.t. Handling of N/R Emergencies

- Government / Executive directives.
- Statutory Regulatory Requirements - under the Atomic Energy Act regarding nuclear safety in general and various Emergency Response Plans in particular.
- Other Statutory Requirements - Rules notified under the Environment Protection Act.
- Obligations due to India being a signatory to certain International Conventions of the IAEA.

Basic Concepts of DAE's ERS

- An Emergency is best managed locally and not by remote control. Role of each and every agency must be clearly defined without any ambiguity.
- Consequently, detailed plans are a must at the local level. Higher levels should be geared up to primarily aid and offer advice if requested, and rarely direct.
- Therefore, at the Plant / Site Level - Plant Emergency and Site Emergency Response Plans - are Plant-specific.
- At the District / State HQ Level - Off Site Emergency Response Plans - are Site- or Location-specific.
- At the National Level - National Crisis Management Plan are Type- or Incident- specific.
- Ensure reliable communications, conduct periodic exercises and have mechanisms to focus resource agencies to the affected location.

Agencies Involved & Resources

- At the local level - Site Emergency Committee - with a Site Emergency Director (SED) or the Off Site Emergency Response Committee (District Collector as OED) or the State Level Emergency Response Committee with access to State's resources.
- At the DAE HQ level - Crisis Management Group (CMG) - with access to resources from all DAE units. Also has also access to identified Resource Agencies - with expertise in the areas of radiation measurement and protection and in the treatment of radiation injuries - who can be directed to the affected site.
- At the National level - NCMC / NCMG, with access to national resources.
- At the International Level - through the IAEA - ERU, ENA TOM, ERNET, JPLAN and REMPAN.

Resources Available

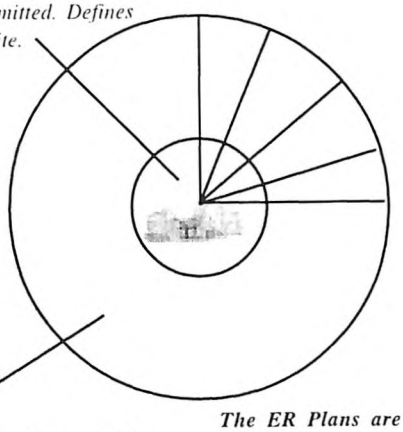
- Personnel / Equipment at 15 different DAE locations in the country - radiation measurement and protection
- At Mumbai, 6 NPPs, 4 Regional Directorates of AMD, NFC, VECC, UCIL, IREL(A)
- Medical Response - at Mumbai, Network at NPPs and later on at national level
- Response Teams from other agencies
- Future plans

Nuclear Emergency Response System
DAE Facilities

- The Regulatory Authority requires all nuclear facilities to have appropriate response systems in place to handle different types of emergencies. These include - Emergency Standby, Personnel Emergency, Plant Emergency, Site and Off Site Emergencies.
- Some of the facilities - the nuclear power stations in particular - are required to have Off Site Nuclear Emergency response plans much before the commissioning of the plant itself.
- The Off Site Response plans are site - specific. They have been drawn up by the respective state governments and are periodically tested and updated.

Resources Available

Exclusion Zone : 1.6 km radius. No habitation permitted. Defines boundary of the site.



Emergency Planning Zone : 16 km radius. Divided into 16 radial sectors and response plans drawn up.

The ER Plans are finalised about 2 years before the plant is commissioned. An Off Site Emergency Exercise is also carried out before commissioning.

Agencies involved in an Off Site N.E.

- Plant/Site Level (Public Domain unaffected) - Plant & Site Emergency Response Committee – Site Emergency Director (SED) is the Station Director or GM.
- Local District Level (Public Domain affected) – OERC - Off Site Emergency Director (OED) is DM or Collector.
- State HQ - State Emergency Response Committee (SERC) - normally chaired by the Chief Secretary.
- DAE HQ Level - Crisis Management Group (CMG) chaired by Additional Secretary, DAE (with Key Officials, support and access to Resource Agencies).
- National Level - NCMC / NCMG.

Typical Resources available to the OED - Roles envisaged for various Departments

Govt. Dept.	Required to carry out the following
• Police	• Alert, Warn, Law & Order, Security
• Transport	• Mobilize transport for evacuation
• Health	• Prophylactics, Keep hospitals ready
• Supplies	• Food at Rallying Points & Shelters
• Home Guards	• Assist Police, Health, other officials
• Fire	• Fire fighting logistics, rescue
• Agriculture	• Agro Sampling, regulation of foodstuff
• DD / AIR	• Broadcast correct information, advice on precautions

Radiation Emergency Response System

(For other types of Radiation Emergencies)

- The Regulatory Authority has its own systems to ensure that authorized users (industries, hospitals, etc.) adopt safe procedures. These include safety audits, periodic checks on the users, qualification and re-qualification of safety officials, etc.
- Simple Guidelines have been circulated to all States and UTs on the handling of nuclear emergencies in the public domain. These include the contact details of the nearest DAE Facility which can respond as well as of the DAE-ECR.
- This enables the DAE-ECR to activate the CMG which in turn can take steps like sending additional response personnel resources from the nearest facility to the affected site.

Radiation Emergency Response System

(Nuclear Material Transport)

- Regulatory requirements require that agencies involved in Nuclear Material Transport are "authorized" - the consignors, transporters and consignees. The procedure must also be an "approved" one to ensure safety and security. The procedure depends on the nature /intensity of radioactive material - ranging from very very low level harmless items like RIA kits which can be sent by post to Spent Nuclear Fuel which requires elaborate arrangements.
- Consignments are required to carry a "TREMCARD" which details the nature of material, immediate actions to be taken in case of an accident.
- To facilitate the "first responders", who would be the local law and order authorities, the contact details of the DAE-ECR are also made available in the TREMCARD.
- This enables the DAE-ECR to activate the CMG which in turn can take steps like sending additional response personnel / resources from the nearest facility or from any DAE unit to the affected site.

Flow of Information During a N/R Emergency

The basic procedure is that the DAE-ECR would get the first information - from any source - which would activate the DAE-CMG

Maintenance of Emergency Response System

- There is nothing like an ideal response plan – what is essential is to have a workable/practical plan based on ground realities and continuously review it to improve it further.
- Experience has shown that the best of plans do not necessarily work as planned during a real emergency.
- Therefore Response Plans need to be maintained properly. Attention to minor details essential at working level.
- In this regard, Communications and Exercises are the backbone of any ERS.
- Communication links essential to ensure better emergency management and exercises a must to ensure preparedness.

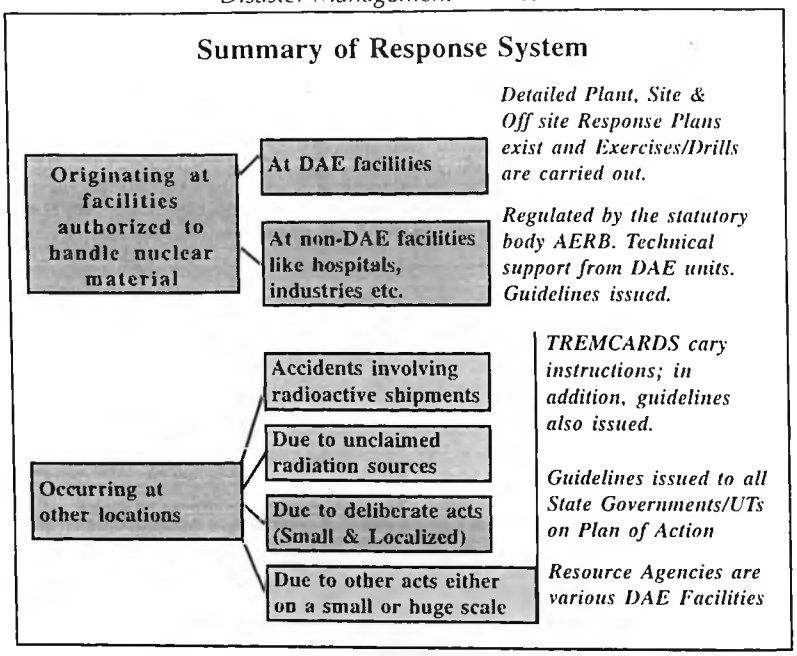
Maintenance of DAE's Response System

A Recap of what has been said so far

- Though radiation cannot be sensed, it can be measured to a very high degree of accuracy.
- Due to the highly sensitive and redundant instrumentation used for radiation measurements, information about an "abnormal situation" would be available sufficiently in advance. Consequently, the declaration of an "emergency" situation does not necessarily mean that personnel have been exposed to "life threatening" radiation levels.
- The safe usage / handling / movement of radioactive materials and the operations of any authorized nuclear site are strictly controlled through detailed and formal systems which are overseen by an independent Regulatory Body.
- Further, unlike as in other emergencies like a fire, accident, explosion, chemical leak, etc., even if an emergency arises (as indicated by increased radiation levels) a time cushion exists. **An instantaneous response is not always essential**.
- In most instances, simple steps like sheltering, shielding, and cordoning would be adequate to begin with, followed by prophylaxis, where required. In rare instances, evacuation could be resorted to at a later stage.
- Therefore, the response plan to a nuclear / radiation emergency in the public domain can be effectively implemented.

Essential Components of DAE's ERS

- Awareness of Framework / Boundary conditions under which it has to function
- Identification of Emergency Scenarios
- Availability of Response Plans which incorporate "Trigger / Alert" mechanisms, at various levels
- Availability of Resources - personnel, equipment and infrastructure - most importantly a reliable Communications Network
- Formal Procedures to maintain the ERS – Periodic Exercises with a feedback and review system to improve effectiveness



In Conclusion

- From the very beginning, users of Nuclear Technology all over the world have been aware of its potential hazards and have therefore ensured safe procedures.
- Nuclear Safety standards / procedures are globally accepted and enforced. Cooperation in this area is unique in this regard.
- To begin with, Safety is ensured in the Design Stage itself to prevent any accident. Further, the design also includes methods / provisions to prevent or minimize the impact in the event of an unlikely accident.
- Over and above these, provisions exist to mitigate the consequences of an unlikely accident and limit it to the plant.
- The Emergency Response System (ERS) is in addition to the above features, so as to respond to possible effects in the public domain.

In Conclusion (continued)

- In this regard, the Department of Atomic Energy (DAE) has a fairly detailed ERS which takes into account statutory reqts., government directives and international obligations.
- The system is decentralized to make it practical. Other agencies (HQ / CMG) are designed to play a supportive role by coordinating with other resource / support agencies.
- This is ensured by a reliable communications network and the system is kept "alive" by frequent exercises of different types.
- DAE will make continuous efforts to enhance the efficacy of this system by periodically reviewing and revising the Plans and upgrading the infrastructure as and when required.
- In today's context the focus is also on further strengthening mechanisms w.r.t. uses of radiation in non-power areas, which also have *potential for an emergency / accident.*

R V SWAMY

Chemical Disasters and their Management

This is a paper on chemical disasters and their management, and my emphasis is going to be on chemical weapons, which have been used both in warfare and by terrorists. I will outline their historical development, provide information on their types and characteristics, and indicate detection methods and countermeasures.

First, I will provide a general overview.

Chemical disasters by themselves can occur during storage, during processing, or during transportation; they can happen because of breakage of walls or containers, leakages, explosions, runaway reactions, and untoward incidents, and because proper precautions have not been taken. Chemicals have certain characteristics – they can cause fires, explosions and have toxic effects.

R. V. Swamy, Chief Controller R & D, (Materials and Life Science), Defence Research and Development Organisation (DRDO) HQrs, New Delhi. 2002. This text is based on the transcript and slide presentation material.

Some gruesome chemical disasters have taken place in our country. You will all be familiar with the Bhopal gas tragedy of 1984, something that we talk about even today. 41 tons of Methyl Isocyanate leaked from storage vessels, and an estimated 2500 people died, with over 80,000 people affected. The incident highlighted safety lacunaa – we were not prepared at all.

After this incident the Factory Act of 1948 was amended and the right to information was instituted, Disaster Management institutions were set up, like the one in Bhopal itself, and environment rules and regulations were promulgated.

In March 1995, there was a transport accident, in which a benzene- laden truck collided with a tractor and a bus. 54 people died. And in September 1997, there was a fire at Hindustan Petroleum Corporation Ltd, Vishakapatnam, caused by leakage of 100 mt of Liquid Petroleum Gas (LPG). In all, 3 X 1200 mt and 7 X 40,000 kl of LPG caught fire. Again, 54 people died, and 65 were injured. I mentioned these just to flag them to you – there were of course several more incidents.

The nodal agency for the management of chemical disasters in India is the Ministry of Environment and Forests (MoEF). The Factory Act of 1948, which I mentioned before, is a key instrument, amended after the Bhopal Tragedy. Also after Bhopal came the Environment Protection Act of 1986, which had rules for protecting land, water and air resources. In 1989, the Manufacture, Storage and Transport of Hazardous Chemicals Rules were promulgated. In 1996 came the Chemical Accident (Prevention and Preparedness) Rules (1996).

All this led to the establishment of a crisis alert system, with crisis management groups constituted at the local, district, state and central levels. A 'national scheme' for capacity building for

chemical emergency preparedness was set up and an off-site emergency plan was initiated, along with training and awareness programmes. Today we have 1436 major hazard installations in 269 districts in the country, and 1309 of these have on-site emergency plans. Model off-site emergency plans exist for nine vulnerable districts. Mock trials have been conducted. Four emergency response centres have been set up at Baroda, Manali, Bhopal, and Khopali. Ten more are to be set up, and there is a poison control centre at the All India Institute for Medical Sciences (AIIMS).

Chemical Weapons

Now, on to chemical weapons. Chemical warfare agents in weaponised form are called chemical weapons. These agents are chemicals that have an adverse physiological action on humans, animals, or plants.

The history of chemical weapons can go well back, but in a modern sense, they were first used in World War I. Phosgene, chlorine, and sulphur mustard were used first by the Germans, who had the most advanced chemical industry at the time. Sulphur mustard is a synthetic chemical, made for this purpose, but phosgene and chlorine are industrial chemicals, with pronounced adverse effects.

The period between the first and second world wars is an important period in the history of the development of chemical weapons. The most dangerous of such weapons came to the fore in this period, like tabun, sarin and soman – the nerve agents of the infamous organophosphorous chemical group. Their physiological actions are immediate and deadly. Chemical weapons were however not used in World War II – both sides knew about their presence in the opposite camp, and maybe they were not considered desirable or useful.

The United States used chemical weapons in Vietnam. The Geneva Protocol was in existence at that time, and what the US

used were defoliants, aimed at destroying foliage.

About two decades ago, tabun and sulphur mustard were used by Iraq in the Iran-Iraq War.

Then there was the terrorist attack using the nerve gas Sarin, in a crowded Tokyo subway in Japan. 13 people died and several were affected.

Characteristics of Chemical Warfare Agents

Toxic chemicals enter the body through the skin, nose (inhalation) and the mouth (oral intake). The first two are involuntary. Toxic chemicals are graded in terms of LD (Lethal Dose)$_{50}$ and LCT (Lethal Concentration X Time)$_{50}$. The LD_{50} number of the chemical, given to those that enter via the skin or the mouth, is the quantity that would be lethal to 50 out of 100 organisms exposed to the chemical. The LCT_{50} number of the chemical, given to those that are inhaled, is the quantity that would be lethal to 50 out of 100 organisms exposed to the chemical. So obviously, the smaller this number, the greater is the toxicity, as it means that smaller amounts of the chemical will result in the same 50 percent lethality.

In many cases, the dose determines whether a chemical is beneficial or poisonous, as the following table shows.

Chemical	Beneficial Dose	Toxic Dose
Aspirin	300 – 1000 mg	1000 – 30000 mg
Vitamin A	5000 units/day	50,000 units/day
Vitamin C	500 mg	5000 mg
Oxygen	20 % (air)	50-80 % (air)

Here are the LD_{50} values of some chemicals. Remember, the lower the value, the greater the toxicity.

Chemical	LD_{50} value in $mg.kg^{-1}$
Ethyl Alcohol	10,000
Sodium Chloride	4,000
Sodium Cyanide	10
Nicotine	1
Sarin	0.2
Soman	0.08
Vx	0.02
Ricin	0.001
Botulinum toxin	0.00001

The last chemical, which is actually a protein form derived from a bacterium, is the most toxic substance known to man today. More on this chemical later.

Chemical warfare agents can be grouped in many ways, but one way to do it is the physiological grouping, based on their effects on humans.

- Nerve Agents
- Blistering Agents
- Blood Agents
- Lung Injurants
- Psychic Incapacitants (which affect brain functioning)
- Riot Control Agents (like tear gas)
- Toxins (based on biological organisms)

Nerve Agents

Nerve agents are organophosphorous compounds and their action, as I mentioned before, is rapid. They are compounds of oxygen, nitrogen, flurorine, hydrogen and phosphorus, and as the name indicates, their action is on the nerves. While the extremely toxic ones are the chemical warfare agents, even insecticides, like Malathion, are actually nerve agents of low toxicity to humans. Their absorption can be by all three routes, namely skin, inhalation and by mouth. They are mostly in liquid form, and are colourless.

Here is a table of LD_{50} values for humans of some nerve agents:

Nerve Agent	LD_{50} (mg/70 kg; oral)
Tabun	25 – 30
Sarin	5 – 20
Soman	5 – 20
Vx	3 – 10
Dicholorvos	300 – 6000
Malathion	4000 – 40,000

Nerve agents act on humans in the following way: they inhibit the enzyme acetylcholinesterase (AChE), which is needed to hydrolyse a neurotransmitter in the body, known as Acetylcholine (ACh). Inhibition of AChE results in accumulation of ACh.

Severe adverse reactions follow. The most important thing to note is the constriction of the pupil (meiosis). Night vision stops, and this effect is very long-lasting. There is increased salivation, perspiration, urination, broncho-secretion and broncho-constriction, tremors and convulsions, and ultimately death due to respiratory paralysis. Exposure of two times the LD_{50} dose will result in death in 10 minutes.

Blistering Agents

The most important blistering agents are Sulphur Mustard, Nitrogen Mustard, Lewisite and Phosgene Oxime. Sulphur Mustard's effects are delayed, with large blisters showing up on the skin only after about 12 hours. They take a long time to heal, around three months, and they may have long-term cancerous effects. They affect the eye as well, resulting in itching, lacrimation and blurred vision. They also affect the respiratory tract. While 100 $mg.min.M^{-3}$ can cause incapacitating eye injury, three to four grams on the skin can be lethal.

Blood Agents

Hydrogen cyanide, cyanogen chloride and sodium and potassium cyanide are some of the blood agents. The first two have high volatility – they boil at room temperature, around 26 degrees, and so are in gaseous form. Sodium and potassium cyanide are in solid form, and are the chemicals terrorists might use to poison water sources.

The effects are immediate – weakness, giddiness, confusion, cardiac irregularities, convulsions, and respiratory failure. Exposure to two times the LD_{50} will result in death in five minutes.

Lung Injurants

These include lung damaging agents, choking agents and inhalation hazards, like phosgene, diphosgene and chlorine. They have respiratory effects followed by respiratory paralysis. Chlorine is slow-acting and a lethal dose will result in death in 24 to 48 hours.

Toxins

Toxins, as I mentioned before, are chemicals derived from living organisms. They can be made from bacterial, fungal, algal, plant, or animal sources. Botulinum toxin is from bacterial sources, as is anthrax. Botulinum toxin can be sourced from the soil under

slaughter houses, for example. A good microbiologist and biochemist can isolate it, culture it, and weaponise it for terrorism purposes, though there would be difficult delivery questions to address.

Countermeasures

Chemical agents can be dispersed in aerosol or liquid form, and the method used may range from spray units, aircraft, bombs and shells, and the like. A terrorist can even bring a nerve agent in a water bottle and throw it in a crowded area, to damaging effect. The ultimate effects will depend on variables like temperature, wind direction and velocity, turbulence, the terrain, the nature of the building, and the like.

There are many methods of detection, and some of the devices required are available in India. Chemical detector paper and residual vapour detection kits indicate the presence of many nerve, blood and blister agents with colour changes. There are detection equipment, based on photometry, spectrometry and chromatography, which can detect even small amounts of nerve and mustard agents. An imported hand-held French or British machine can cost about Rs five to eight lakhs. An Indian one is also available, but it is a table top model.

A standard protective measure is physical protection, using an overbody suit, with hood, face mask, canister, body suit, gloves, and overboots. DRDO has developed such a suit, and we have supplied it to various agencies. You can be in a hostile environment for upto six hours in such a suit. DRDO has also developed a shelter where 30 people can stay for about seven days.

For decontamination of an affected area, one can use chemicals to break the chemical bonds of the agents, using special equipment and vehicles to deliver the decontaminants, which DRDO has developed.

Some medical countermeasures are also available. For nerve agents and for cyanide, treatment would include artificial respiration and drugs like Atropine, Oxime, and Diazepam. Blistering agents would have to be treated like burn injuries, petroleum jelly and cirpofloxacin drops for the eye being quite useful. For the skin, Povidone – iodine ointment and Framycetin ointment can be used. Amyl nitrite, sodium nitrite and sodium thiosulphate can be used for blood agents. There is no specific treatment for lung injurants (apart from artificial respiration and use of codeine, corticosteroids and antibiotics) and for toxins.

K V VENKATACHARY

Space Technologies in Disaster Management

1. Introduction

The Indian landmass is prone to several natural disasters such as floods, cyclones, landslides, earthquakes etc. While the east and west coasts are prone to severe cyclones, most of the major river systems such as the Ganges and the Brahmaputra are prone to large–scale flooding affecting over 40 million ha every year. The hilly tracts of the Himalayas are prone to major landslides associated with heavy rainfall. Two-thirds of the country are prone to earthquake. The super cyclone that hit the Orissa coast in October 1999 and the devastating earthquake that affected Gujarat State in January 2001 are some of the recent major events. Statistics of the disaster events show an alarming trend of increasing damage and economic loss due to increasing population and development activities in vulnerable areas.

An ideal Disaster Management System needs to support the activities related to preparedness, prediction, damage assessment and rehabilitation. Space-based systems from their vantage position have unambiguously demonstrated their capability in

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providing vital information and services in a disaster situation. Space-based systems provide valuable inputs and are the only tools that remain unaffected by the impact of an event for assessing vulnerability whenever a disaster event occurs over a region. Space inputs could be used in taking preventive measures through vulnerability analysis, hazard zoning and prior risk assessment at regional and local levels. Satellite-based weather forecasts and advance warning of severe weather will minimize loss of life and damage and facilitate timely and effective rescue, relief and rehabilitation of the affected population.

The various phases of disaster management and the activities involved in these phases are as follows:

- Pre-disaster planning/prediction/preparatory phase
- Warning and emergency relief/response phase
- Post-disaster rehabilitation and reconstruction/recovery phase

Pre-disaster planning/prediction activity is the process of preparing in advance to meet a disaster event. In the warning phase, people at risk are given adequate notice or warning to prepare for the disaster and, if necessary, to evacuate.The rehabilitation and recovery phase involves both short-term and long-term activities designed to restore vital life support systems to minimal operating standards.

2. Space systems in disaster management

For evolving the disaster management framework, it is imperative to identify for each disaster the information needs and sources, carry out a risk assessment or vulnerability analysis, provide prediction and warning of disaster occurrence, and draw up rehabilitation plans. Space systems can make substantial contributions in providing vital information and services in all three phases of disaster management. Many of these contributions can be made with existing satellites and sensors. Earth-orbiting satellites have reached an advanced state of complexity and diversity. They can be conveniently divided into four categories:

communication, meteorology, remote sensing and geophysical information.

Communication satellites have gained by far the greatest practical use. Broadband satellite transmission of Voice, Video and Digital business data has become a cornerstone of the communication industry, generally via satellites in equatorial, geostationary orbit. Less well known though also of importance in disaster management are the capabilities of unmanned ground stations and geosynchronous satellites in transmitting environmental data. The SARSAT COSPAS system, which transmits alert signals from foundering boats, downed aircraft and other vehicles in distress, is an important example of this capability.

The satellites are capable of providing synoptic and repetitive coverage and are ideally suited for disaster monitoring and mitigation. Meteorological satellite observations of regional cloud distributions in real time from geosynchronous satellites are used for monitoring severe weather systems and for forewarning. Remote sensing satellites are used to observe, map and monitor features and phenomena on the Earth's surface. Such satellites have an extremely wide range of potential applications relevant to disaster management. Geophysical satellites play a significant role in observing geophysical phenomena at or near the Earth's surface, monitoring the ocean surface, for example, or detecting minute changes in ground movements.

3. Current capabilities of space systems

3.1 Remote sensing satellites

The Indian Space Programme began its remote sensing activities using aerial photography in the early 1970's and graduated to satellite remote sensing with the experimental remote sensing satellites – Bhaskara-1 and Bhaskara-2 launched in 1979 and 1981 respectively. With the experience gained from these experimental satellites that carried TV cameras for imaging with a resolution

of 1 km and passive microwave remote sensors in 19.22 and 31 GHz bands. ISRO ventured into the operational remote sensing era with the successful launching of the first Indian Remote Sensing Satellite (IRS 1A) in 1988. Both IRS 1A and the follow-on satellite IRS 1B launched in 1991, carried LISS cameras employing 2048-element Charge Coupled Devices (CCD) operating in the push-broom mode to provide imageries in four spectral bands with a resolution of 72.5 and 36.25 metres. IRS 1C and IRS 1 D incorporate improved LISS sensors designed to provide multi-spectral information at 23.5 m resolution and a middle infrared sensor with a resolution of 70.5 m over a 140 km swath strip in addition to the panchromatic imageries with a resolution of 6.5 m employing 4000 and 6000 element CCDs. The addition of Wide Field Sensor (WiFS) that can image 770 m swath strips with a resolution of 188 m is an additional feature for deriving vegetation index on a much finer scale and rapid monitoring of drought and vegetation conditions which so far have been limited to the use of NOAA imageries with a resolution of 1 km. IRS 1C and 1 D also incorporate stereo viewing capability extending to a range of $\pm 26^0$. Three of the most important operating systems now available on a worldwide basis are Landsat, IRS and SPOT.

Microwave remote sensing has already established its potential for becoming a truly powerful all-weather remote sensing system because of its ability to penetrate cloud cover, haze, smoke, rain, and snow, which is the basic limitation in optical remote sensing. A passive microwave radiometer basically consists of an antenna for receiving incoming radiation, a scanning mechanism and a sensitive receiver to measure incoming radiation. A large number of passive microwave radiometers operating at different frequencies have been flown in various satellites primarily for meteorological and oceanographic studies. The development of active microwave systems such as imaging radars, scatterometer and altimeter promise to add a new dimension to our earth observation capability with their ability to provide imagery with a resolution approaching that of optical remote sensing, under all weather conditions.

3.2 Geophysical satellites

The USA and other countries have launched many satellites to explore aspects of the Earth's environment including particle and energy fluxes from space and the earth's magnetic and gravity fields. Precise mapping of the gravity field was a by-product of tracking of satellites. Satellite orbit prediction carried out precisely to within a few centimetres has led to several applications of potential interest in disaster mitigation.

It is now possible using a satellite-borne microwave altimeter to measure the sea height to within five to ten centimetres. Laser tracking from ground to satellites with retro-reflectors permits determination of baseline lengths to within centimetres. The Indian satellites IRS P3 (with Modular Optoelectronic Sensor – MOS) and IRS P4 with Microwave Scanning Radiometer – MSMR) gave observations on geophysical parameters related to the atmosphere and ocean. Repeated observations of baselines in earthquake–prone regions can detect build up of strain that may indicate an impending earthquake. The US Navy's Global Positioning System (GPS) is also being used for similar purposes.

3.3 Meteorological satellites

Geostationary meteorological satellites have a distinct advantage over low earth-orbiting satellites because of their capability to image on a continuous basis over large areas, which is particularly important for tracking cyclones and measuring wind vectors derived from the displacement of specific cloud features in successive imageries. Many of these satellites have also incorporated data collection platforms which can periodically interrogate meteorological information from unattended platforms located in inaccessible and remote areas and transmit them to a central location. In spite of the great advantage of geostationary

meteorological satellites providing round-the-clock observations at frequent intervals the fact that such satellites are unable to provide polar and high altitude coverage makes it difficult to have both geostationary and low-orbiting global weather monitoring. The INSAT systems in operation over the past two decades are giving meteorological observations over the Indian region through the very high resolution radiometer operating in visible and thermal channels. The observations include Cloud Cover, Cloud Motion Vectors (at 3 levels), Sea Surface Temperature and Outgoing Long Wave Radiation. Several types of polar-orbiting meteorological satellites have been launched by the USA including NOAA's TIROS, NASA's NIMBUS.

3.4 Communication satellites

The advent of satellites has revolutionalised the communication scenerio. The capability of satellites to cover large areas (footprints) has been effectively used to cover most parts of the globe. The satellites also permit operation in broadcast mode so as to deliver voice and video data to large areas. ISRO has operationalised satellite communication in the country through the INSAT series of satellites. Communication capabilities include mobile telephony and VSAT-based communications, which are useful in providing emergency communication in disaster-affected areas. User departments of data are using the communication and broadcasting capabilities of INSAT for dissemination. The vast capabilities of communication satellites are available for timely dissemination of information on early warning and for real-time co-ordination of relief operations. Satellite communication, in particular, provides a wide variety of services, viz. truck route communications, remote and rural area communications, emergency communications, business communications with roof to very small aperture terminals (VSATs), mobile communications (INMARSAT, Mini M), TV distribution and broadcasting, radio distribution, data distribution, etc. The capabilities of Indian satellites in terms of diverse applications are given in Table 1.

Table 1. Key application areas of Indian Satellites

Sl. No.	Satellite	Spatial resolution (m)/swath (km)	Repeat cycle (days)	Application areas
1	IRS-IA	LISS-I: 72.5/148	22	Earth resources. survey and management of
2	IRS-IB	LISS-II: 36.25/148		resources in areas like agriculture. geology and hydrology
3	IRS-IC	PAN: 5.8/70.5 LISS-III: 23.6/141 : 70.8/148 WiFS: 188/774	24	Agriculture. forestry. urban. land use. soil. geology. terrain. water resources. DEMs. environment. disasters (damage assessment/relief)
4	IRS-P3	WiFS: 188/810 MOS-A: 1570/195 MOS-B: 525/200 MOS-C: 645/192	5	Remote sensing of earth resources. study of X-ray astronomy. periodic calibration of PSLV radars located at tracking stations
5	IRS-ID	PAN: 5.8/70.5 LISS-III: 23.6/141 : 70.8/148 WiFS: 188/774	24	Agriculture. forestry. urban. land use. soil. geology. terrain. water resources. DEMs. environment disasters (damage assessment/ relief)
6	IRS-P4	OCM: 360/1420 MSMR: 120. 80 40/1360 PAN: <2.5/13	2	Systematic data for oceanography. coastal. atmospheric applications
7	INSAT-1	Visible & TIR	Continuous	Clouds. CMVs (2 level). SST. QPE. OLR
8	INSAT-2	Visible. TIR. WV & CCD		Clouds. CMVs (3 levels). WV image. QPE. OLR
9	INSAT-3	Visible. TIR. WV & Sounder. CCD		Clouds. WV image. SST. OLR
10	METSAT	Visible/thermal. sounding. water vapour		SST. Cloud. CMVs. WV. mesoscale. temp./humidity profiles

CMVs - Cloud Motion Vectors; QPE - Quantitative Precipitation Estimate; SST - Sea Surface Temperature; OLR - Outgoing Longwave Radiation; WV - Water Vapour; DEM - Digital Elevation Model

4. Potential applications of remote sensing data

In more ways than one, remote sensing is ideally suited for disaster management. First of all, it provides a database from which the evidence left behind by disasters that have occurred before can be interpreted, and combined with other information to derive hazard maps. Satellite images give a synoptic overview and provide very useful geomorphologic information, for a wide range of scales, from entire continents to details of a few metres. Secondly, many types of disasters, such as floods, drought, cyclones, volcanic eruptions, etc. will have certain precursors. Satellites can be used to detect the early stages of these events as anomalies in a time series. Images are available at regular short time intervals and can be used for the prediction of both rapid and slow disasters. When a disaster occurs, the speed of information collection from satellites and the possibility of information dissemination with matching swiftness make it possible to monitor the occurrence of the disaster. Many disasters may affect large areas and no tool other than remote sensing would provide matching spatial coverage. Remote sensing also allows us to monitor the event at the time of occurrence while the forces are in full swing. The impact and departure of the disaster event leave behind an area of immense devastation. Remote sensing can assist in damage assessment and aftermath monitoring, providing a quantitative base for relief operations. Finally, satellite data can be used to map the new situation and update the databases used for the reconstruction of an area, and to prevent recurrence of such a disaster. The following sections give a brief summary of various applications of satellite data for operational disaster management.

4.1 Cyclone monitoring and warning

Meteorological satellites are valuable for monitoring and forecasting cyclones. INSAT/VHRR images are being used to identify cloud systems over the oceans, where no observational data is available, as well as for cyclone tracking, intensity assessment and prediction of storm surges, etc. They need to be supplemented with ground meteorological observations and radar

data for accurate assessment of rainfall intensity. An innovative use of INSAT has been in the implementation of the unique, unattended, locale-specific Cyclone Warning Dissemination System (CWDS) consisting of over 250 disaster warning receivers installed in cyclone-prone areas of the country, designed to provide warning to coastal villages about an impending cyclone. Since the commissioning of Disaster Warning System and its first operational use for disaster warning in 1987, CWDS has become a vital disaster mitigation mechanism. Current research around the globe is concentrating on the use of meso-scale models with satellite data inputs to improve cyclone intensity and track prediction.

4.2 Flood management

Despite limitations of cloud cover and a long revisit period, satellites have been providing vital information towards (i) precipitation forecast and warning (ii) inundation mapping and damage assessment and (iii) flood plain management. Recent advances in using microwave data, especially to address the persistently cloud-affected areas, have enhanced the potential use of remote sensing by virtue of its all-weather capability. Besides providing inputs for quantitative estimation of precipitation, geo-stationary satellites have become increasingly helpful for collection of data on rainfall, river stages, etc., for remote, uninhabited locations over land.

4.2.1 Inundation mapping and damage assessment

Mapping of flood-affected areas is one of the most successful applications of satellite remote sensing in flood management. Because of the unique spectral signature, it is possible to map areas under standing water, areas from where flood water has receded, submerged standing crop areas, sand casting of agricultural lands, breaches in embankments, marooned villages and towns, etc. Using multi-date satellite imageries, the extent of damage due to crop loss, destruction of infrastructure facilities, etc. can be assessed. Space technology for flood monitoring and management has been successfully operationalised in India. Near real-time monitoring and damage assessment of all major flood

events are being carried out operationally. Satellite remote sensing and GIS techniques have been integrated [12] in the Brahmaputra river basin to provide information on flooded area and damage to croplands, roads and rail tracks. A Global Positioning System (GPS) is being used to aid in the development of a Digital Elevation Model (DEM) for a flood-prone area in Andhra Pradesh, to enable assessment of spatial inundation at different water levels in the river. When satellite-derived land use/cover and ancillary ground-based socio-economic data is draped over the DEM, flood vulnerability can be assessed to provide location-specific flood warnings. Remote sensing data are evaluated for integration with existing forecasting models. Also, microwave data from RADARSAT is used in conjunction with optical data to overcome the limitation of cloud cover.

4.3 Drought management

Drought management involves development of both short-term and long-term strategies. Short-term strategies include early warning, monitoring and assessment of droughts while long-term strategies aim at drought mitigation measures through proper irrigation scheduling, soil and water conservation, cropping pattern optimization, etc. Early warning of drought is useful for on-farm operations and to arrive at an optimal local water utilization pattern. Rainfall anomalies as observed from geo-stationary/meteorological satellites are being used for early warning of drought, but this is yet to be fully operationalised. Studies have indicated that certain large-scale meteorological patterns are associated with the failure of the summer southwest monsoon, which is the main cause of droughts in the Indian subcontinent. Factors that can provide early indication of possible droughts include upper air winds over India, development of hot low-pressure areas over southern Asia, and the El Nino/Southern oscillation phenomena in the Pacific Ocean. Other factors that can be observed by satellites and which are related to rainfall patterns are sea surface temperature, snow cover, cloud patterns, wind velocity and direction, and atmospheric temperature/humidity profiles.

Monitoring and assessment of droughts are required for taking corrective measures at appropriate times to minimise the reduction in agricultural productivity in drought-prone areas. The satellite-derived vegetation index (VI), which is sensitive to moisture stress is now being used continuously to monitor drought conditions on a real-time basis, often helping the decision-makers initiate strategies for recovery by changing cropping patterns and practices. A remote sensing-based National Agricultural Drought Assessment and Monitoring System (NADAMS) for countrywide monitoring in India has been developed. Monthly drought assessment reports are being generated under NADAMS. With the operationalisation of IRS-1 C WiFS and IRS-P3 WiFS and SWIR bands, in-season agricultural drought monitoring capability has been further improved.

Drought-proofing requires an integrated approach taking into account the multi-dimensional inter-linkages between various natural resources and the environment on the one hand, and the mutual inter-dependencies of natural resources on the other. A satellite remote sensing-based Integrated Mission for Sustainable Development (IMSD) is a unique Indian experience to evolve action plans towards combating droughts against the backdrop of socio-economic conditions of the watershed. The integrated approach of utilising the existing conventional data with satellite remote sensing data assumes greater importance in developing operational methodologies in basic resource mapping and management to formulate long-term drought mitigation measures. With the integration of remotely-sensed data and conventional information through GIS, site-specific solutions are evolved. The implementation of these action plans has resulted in (i) reducing the runoff loss by about 50% (ii) rise in water level from 0.9 to 5 m due to the impact of check dams and percolation tanks and (iii) enhanced agricultural productivity.

4.4 Earthquakes

Earthquake risk assessment involves identification of seismic zones through collection of geological/structural, geophysical (seismological) and geomorphologic data and mapping of known

seismic phenomena in the region (mainly epicentres with magnitudes). Satellite imagery could be used in delineating neotectonic structures and to clarify seismo-tectonic conditions in earthquake risk zones. Accurate mapping of geomorphologic features adjoining lineaments reveals active movement or recent tectonic activity along faults. Studies carried out earlier have highlighted the correlation between major lineaments and the seismic activity in Latur area in Maharashtra, India. It was observed that between 1967 and 1977, about 100 earthquakes (86 in Koyna region alone) of intensity 4 or above on the Mercalli scale occurred in the Southern Peninsula. Most of these have been found to occur in the vicinity of NNE-SSW to NW-SE trending mega lineaments.

4.5 Landslides

A number of studies have been carried out in India using satellite data and aerial photographs to develop appropriate methodologies for terrain classification and preparing maps showing land hazard zoning. Using GIS techniques, the thematic layers on geology, soils, slope, land use/cover, etc. are suitably integrated to arrive at relative classes of landslide zoning. Such work has been carried out for the Garhwal Himalayan region, Nilgiri Hills in Southern India and in the Sikkim forest area. In the Tehri dam reservoir periphery, these imageries have helped in identifying 71 potential landslide areas. The studies are to be supplemented by aerial photographs for high-resolution contour mapping with intervals .of better than 2 m.

4.6 Forest fires

Satellite imagery in the infrared region and ground/aerial photographs have been employed to map areas damaged by forest fires and assess the extent of area that needs to be reclaimed. Thermal infrared sensors on board the NOAA/ A VHRR and IRS have been used for monitoring moisture conditions and assessment of forest fire-prone areas. The normalised difference vegetation index (reflectance ratio of NIR and IR) was the most suitable for mapping burnt areas.

4.7 GIS database applications in disaster management

The success of disaster management largely depends on availability, dissemination and effective use of information. The information needs include current information on weather, infrastructure (roads, hospitals, administrative boundaries), demography, etc. to assess the disasters. Currently such data are being generated by multiple users and stored in multiple formats and media, making it difficult to bring the data together to support disaster management activities. In addition there is a need to assess the disaster in terms of location, extent and likely impact so as to plan relief and recovery actions. An integrated system adequately equipped with necessary infrastructure and expertise to constantly monitor the risk profiles on all possible disasters and maintain a national database will become relevant. In this context, the GIS technique offers a tool to analyse multiple layers. The critical thematic layers required for various disasters are given in Table 2.

Table 2: GIS layers for various disasters

Thematic Layers Disaster	Landuse /Cover	DEM/ DTM	Hydro-Geomor-phology	Soils	Geology/ tectonics	Watershed/ Drainage	Isohydal	Admin. boundary	Infra-structure
Drought	1	3	1	1	-	1	1	1	1
Flood	1	1	3	2	-	2	1	1	1
Cyclone	1	1	3	3	-	3	2	1	1
Landslide	2	1	1	1	1	2	1	1	1
Earthquake	2	3	1	2	1	2	3	1	1
Forest fire	1	3	3	2	-	-	1	1	1

Priority: 1 - Highest priority; 2 - Medium priority; 3 - Low priority

One of the crucial aspects of disaster management is the availability of reliable information in a timely manner. Information helps in minimising damage by warning the affected population, helping in planning relief and resilient solutions for rehabilitation and recovery. The disaster management system should have a good networking of the data providers, administrators and affected population, NGOs, relief workers, support agencies, etc. In the real sense, disaster management calls for synergy of technologies and interaction of different agencies. Multi-agency interface will lead to institutionalisation of disaster management.

5. Satellite communication for disaster management

Significant developments in satellite communication capabilities and the availability of low-cost, small terminals for communicating even to remote and inaccessible areas have become invaluable aids for communication of disaster alerts and providing timely relief to people in disaster-affected areas. The global availability of mobile communication systems in the near future will further enhance our capability by enabling us to quickly locate disaster-stricken groups and vehicles. Communication assumes greater importance especially during cyclone, flood, etc. where predictability, forecasting and early warning hold the key to disaster preparedness. Effective and reliable communications hold the key to disaster prevention and mitigation, especially towards:

- Disaster alerts
- Locating the disaster-stricken area
- Continued accurate and timely monitoring and assessment of the current status of damage and post-disaster situation
- Efficient delivery of aid and co-ordination with the central relief management agency.

Emergency communication is suported by systems such as Very Small Aperture Terminals (VSATs), mobile communications (INMARSAT Mini M, INSAT MSS Reporting Terminal), TV /

radio broadcasting, etc. Data relay and communication satellites have the ability not only to deliver early warnings on various disasters, but also to disseminate requisite information on awareness and educate the local people and prepare them to face such hazards. Locale-specific unattended Cyclone Warning Dissemination Systems (CWDS) installed by India along the vulnerable eastern and western coasts of the country, using the communication and meteorological capability of INSAT multipurpose satellites, have been of immense value in providing timely warning on cyclones in the last 10 years. The vast capabilities of communication satellites are available for timely dissemination of information on early warning and real-time coordination of relief operations. The advent of Very Small Aperture Terminals (VSATs) and Ultra Small Aperture Terminals (USATs), and Phased Array Antennas has enhanced the capability further by offering low-cost, viable technological solutions for management and mitigation of disasters. Satellite communication capabilities - fixed, mobile, personalised - are vital in a large number of disaster management situations, especially in data collection, distress alerting, position location and coordinating actual relief operations in the field. In the area of disaster preparedness/ mitigation, inputs from satellite data can assist in making vulnerability analyses and help decision-makers evolve short - and long-term strategies for disaster mitigation.

5.1 Search and rescue system

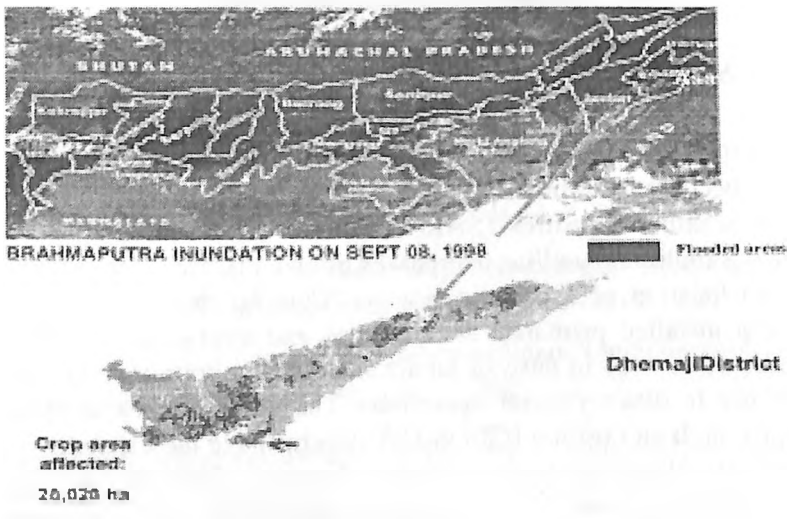
An international programme for transmission of distress signals has become operational using transponders on board Russian and US weather satellites (SARSAT/COSPAS). Doppler tracking using multiple satellite overpasses allows precise (within a few km) location of a distress beacon. Thus far the beacons have been installed primarily aboard ships and aircraft, so that they may be located in case of an accident. The system may also be of use in disaster relief operations. The geostationary satellites for search and rescue (GEOSAR) systems have the capability to provide almost immediate distress location. Since INSAT 2A, INSATs have search and rescue transponders. Geostationary

satellites, while not being able to locate the site of the emergency, can relay messages without the delay that might occur in the case of polar orbiting satellites as they are not always in sight of an emergency.

6. Pilot-scale study of the Brahmaputra floods

A pilot-scale study was initiated [2] by ISRO to design a prototype system that will integrate space inputs with conventional data. The study area selected was the Brahmaputra floods in Assam. The system consisted of comprehensive database design, space-based near real-time monitoring tools, modelling framework, networking and user interface. With appropriate synthesis of these core elements, flood monitoring and damage assessment were carried out during 1998-2001 for selected districts in Assam. A typical satellite-based flood map at district level showing marooned villages is shown in Fig. 1. Through use of networking, the space-based inputs were disseminated to the users. The study has led to a realistic assessment of the gaps in the current system and conceptual framework for a disaster management system.

Fig. 1: Monitoring of Brahmputra Floods in Assam



The pilot project could demonstrate the compatibility of space applications with conventional systems and enable better quality of information in terms of spatial scale (up to village level using high resolution satellite data) and temporal scale (turn-around time of a few hours). It was possible to map out village level inundation with affected population (including livestock), damaged crops and marooned infrastructure, and thus fill the gap between user needs down the line and space applications.

7. Space-based disaster management support

With the vast experience gained through pilot-scale studies and operational use of space data, the concept of a space-based observation and communication system for disaster management is being evolved in the country. The most important need is to assess the overall requirements of users at various levels and the delivery mechanisms that could provide the services effectively towards monitoring, forecasting, warning, assessment, prediction, and reduction of natural disasters. Information is required by disaster managers in each of the critical phases of disaster management, which includes mitigation and preparedness, response and recovery/relief. Such a system therefore will consist of: (i) database design (ii) near real-time monitoring/mapping (iii) modelling framework (iv) networking solutions and (v) multi-agency interface.

Taking into account all the institutional, operational and technological factors that constrain space applications to disaster management, ISRO/DOS planned to set up a mechanism that encompasses several capacity-building measures,viz. establishment of a Decision Support Centre (DSC) interfacing with National/State disaster management systems, re-organising the infrastructure for real-time and conjunctive use of aerial and satellite services, and supportive R & D efforts. The main objective of this service is to provide timely information meeting user needs in terms of information content, turn-around time and format. Such information will be disseminated to the State and

Central user agencies. The important components of the Decision Support Centre (DSC) of ISRO will include:

- Satellite/aerial data acquisition strategy
- Turn-around time for data analysis and output generation
- User-oriented information and formats
- Dissemination to users and networking
- Support facilities such as digital database, hazard zoning, modelling, query-shell, etc.

A schematic giving the proposed interface mechanism is given in Fig. 2. Finally, DSC will evolve as a single-window information service provider to start with, while the long-term vision is diffusion and internalisation of Space applications to the line departments. ISRO/DOS is building up the necessary men and machinery to operationalise DSC with active support from other agencies. DSC will evolve into an integral part of the National Response Mechanisms for Disaster Management in the country.

8. International Charter on Space and Major Disasters

Considering the potential contribution that space can provide to the prevention and mitigation of natural disasters, an initiative was launched by ESA and CNES in the year 2000, namely the International Charter on Space and Major Disasters. ISRO joined the Charter in September 2001, after due governmental approval. Currently, NOAA and the Canadian Space Agency are the other members of the Charter, in addition to CNES and ESA. The Charter is aimed at efficient use of space technology in disaster management by developing a long-term working relationship between civil protection authorities and space agencies. In the event of a major disaster, the member countries interact and decide on the best way to provide critical information based on space inputs. Support to the Charter by the members is voluntary and limited to the availability of requisite resources. In order to support participation in the International Charter and provide the required

inputs in a timely manner, appropriate mechanisms are being established in ISRO.

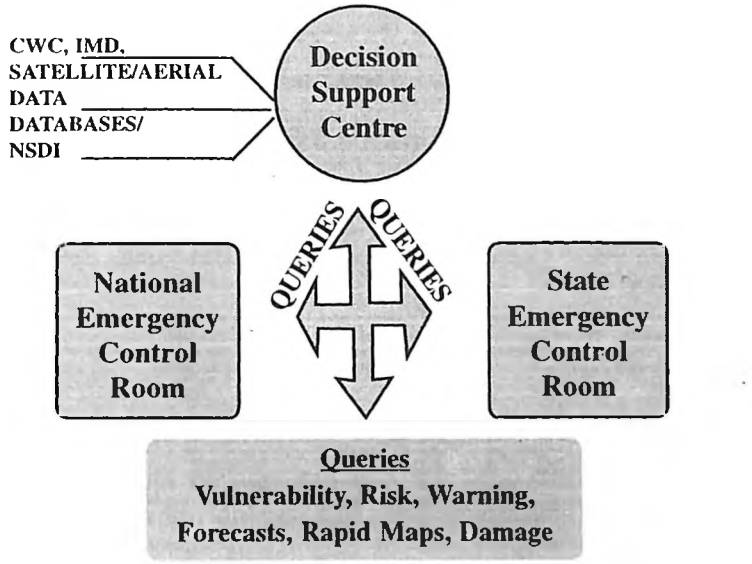


Fig. 1. Decision Support Centre (DSC) - Institutional Mechanism towards Info Support for Disaster

9. Conclusions

The recent developments in space technology in terms of communication and remote sensing have led to improved capabilities to support disaster management. In several areas such as cyclone monitoring, flood mapping, landslide zoning etc. satellite remote sensing has become operational. The emergency communication and warning systems have become an integral part of disaster management. The future thrust areas are improved forecasting through use of models, networked systems for on-line decision support and advanced communication systems for warning and relief.

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Greenhouse Gases, Aerosols and Climate Change

Introduction

There has been a serious concern that the global warming observed during the past two decades may be on account of emission of carbon dioxide and other gases due to burning of fossil fuels by human beings. In 1988, the United Nations constituted the Intergovernmental Panel on Climate Change (IPCC) to examine the scientific evidence on climate change. The IPCC has published several monographs that highlight our present understanding of the impact of human activities on our climate. We know now that most of the warming that has been observed during the past 100 years is mainly on account of human activities. The burning of fossil fuels and biomass by human beings releases carbon dioxide, sulfur dioxide and soot into the atmosphere. The increase in carbon dioxide in the atmosphere will lead to warming of the atmosphere while the increase in sulfur dioxide will lead to cooling of the atmosphere. The presence of soot will lead to cooling of the surface of the earth and warming of the lower atmosphere. Hence the net effect of increase in carbon dioxide, sulfur dioxide, and soot on climate can be quite complex. We examine these issues in this paper.

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Climate and Greenhouse Gases

The climate of the earth is strongly controlled by a few minor gases. This is because nitrogen, oxygen and argon that constitute 99.93% of the earth's atmosphere do not absorb most of the incident solar radiation or the radiation emitted by the earth's surface. Hence, a few minor gases control the climate of the earth. Some of these gases are water vapour, carbon dioxide, ozone and methane These gases constitute less than 1% of the earth's atmosphere but have a profound influence on the earth's climate They are called greenhouse gases because their radiative properties are similar to that of glass that is used in greenhouses. They absorb 95% of the radiation emitted by the earth but absorb only 15% of the solar radiation. The presence of these gases in the earth's atmosphere has made the surface temperature of the earth warmer by about 33° C and hence more habitable for human beings.

During the past two hundred years the amount of carbon dioxide has increased from around 280 parts per million (ppm) in 1850 to 368 ppm in 2000. During the same period the global mean surface temperature of the earth has increased by 0.6 to 0.8 °C. The increase in the global mean temperature of the earth during the past 100 years is primarily on account of the increase in carbon dioxide and other greenhouse gases. Human activities, such as fossil fuel burning and biomass burning, release about 7 GtC (giga tons of carbon) of carbon dioxide per year. A part of the carbon dioxide released by human activities is absorbed by the ocean and the biosphere while what remains in the atmosphere increases the concentration of carbon dioxide by around 1 to 1.5 ppm per year. The emission of carbon dioxide per capita by human beings in developed countries is about 8 times larger than the emission by human beings in developing countries. Hence the major responsibility to arrest global warming due to increase in carbon dioxide lies with the developed countries.

In the Kyoto protocol adopted in 1997 it was agreed that developed countries would reduce the emission of greenhouse gases by 5.2% by 2008-2012. In 1999 the United States decided that it would not reduce the emission of greenhouse gases unless

developing countries are also asked to reduce the emissions. This has caused a stalemate in negotiations to reduce greenhouse gases such as carbon dioxide.

Earth's climate is also strongly influenced by the spatial extent of the polar ice caps. The climate of the earth has not remained invariant during the past 4 billion years. There have been periods, called ice ages, during which the global mean temperature was more than 5° C below the present. During ice ages the amount of carbon dioxide and methane was much lower than at present. This demonstrates clearly that there is a correlation between the amount of carbon dioxide or methane in the atmosphere and the global mean temperature. In addition to greenhouse gases such as carbon dioxide and methane, the earth's climate is also influenced by aerosols.

Aerosols and Climate

Aerosols are tiny liquid or solid particles suspended in the atmosphere. They are created naturally or by human activities. Natural aerosols are dust, sea salt or sulfate. Natural aerosols have influenced the climate of the earth. After a major volcanic eruption a large amount of aerosols are deposited in the stratosphere and their residence time is of the order of years. These aerosols increase the reflectivity (also called albedo) of the earth-atmosphere system and hence lead to the cooling of the atmosphere and the surface of the earth.

The aerosols released by human activities, such as sulfate and soot, are confined to the lower troposphere and hence their residence time is usually less than a week. The impact of aerosols on human health has been investigated for a long time but their impact on climate has been addressed only recently. The global emission of sulfur dioxide on account of human activities has increased from around 10 Tg of sulfur per year in the beginning of the 20th century to more than 90 Tg of sulfur per year at the end of the 20th century. The amount of sulfur dioxide emissions from India is about one sixth of the emissions from North America, Europe or China. The present global emission of sulfur dioxide

by human activities is almost four times larger than the natural flux of sulfur dioxide. Hence there is a new concern about the impact of anthropogenic aerosols on climate.

The changes in radiative flux (at the top of the atmosphere) on account of increase in greenhouse gases or aerosols is called Radiative Forcing. The human activities which increase tropospheric aerosols can alter the radiative forcing directly as well as indirectly. Direct radiative forcing by aerosols occurs on account of the changes in reflectivity (i.e. albedo) and absorptivity of the atmosphere that occur due to the presence of these aerosols. Indirect radiative forcing by aerosols occurs on account of their modification of the lifetime of clouds and their radiative properties. The burning of fossil fuels increases the amount of carbon dioxide and sulfur dioxide in the atmosphere. The increase in carbon dioxide in the atmosphere causes an increase in surface temperature of the earth on account of the greenhouse effect. On the other hand, an increase in sulfur dioxide leads to an increase in sulfate aerosols. The sulfate aerosols reflect solar radiation back to space and hence reduce the surface temperature of the earth. Thus the burning of fossil fuels has caused both heating and cooling of the surface of the earth.

The warming of the surface of the earth due to increase in carbon dioxide has dominated the cooling due to increase in sulfate aerosols. When the effect of aerosols is included in climate models they are able to simulate more accurately variation of global mean temperature during the past 100 years. The residence time of carbon dioxide in the atmosphere is of the order of one hundred years while the residence time of sulfate aerosols is of the order of weeks. Hence carbon dioxide concentration in the atmosphere is almost the same all over the world while the concentration of sulfate aerosols is large in the regions where sulfur dioxide emissions are large and small in other regions.

The global mean radiative forcing by greenhouse gases and aerosols from pre-industrial times to the present has been reported by IPCC. The greenhouse gases contribute 2.5 W/m^2, with the

dominant contribution being from carbon dioxide (1.5 W/m^2). The next important greenhouse gas is methane (0.5 W/m^2). Chloroflurocarbons such as Freons (used in refrigerators) contribute less than 0.5 W/m^2. Their contribution will decline in the 21st century since their emissions will reduce on account of the Montreal protocol signed in 1988. The Montreal Protocol was adopted in 1988 after it became clear that chloroflurocarbons caused the reduction of ozone in Antarctica.

Climate Models

In order to understand the impact of aerosols and greenhouse gases on future climate we need to use climate models. These models, called General Circulation Models (GCM), use the basic laws governing the conservation of mass, momentum and energy all around the globe (Drake, 2000). The entire atmosphere of the earth is divided into a large number of small boxes. The typical dimensions of each box are 200 kilometres in longitude, 200 kilometers in latitude and 1 kilometer in height. The temperature and winds in each box are calculated using the physical laws governing the conservation of mass, momentum and energy. The moisture content is calculated by ensuring the conservation of water in all its forms (liquid, solid and vapour) in each box. The representation of clouds in climate models is crude because the typical size of the cloud is much smaller than the size of the box. The clouds are represented in these models based on certain assumptions. Hence different modelling groups have represented clouds and their impact on climate in different ways in their climate models.

The presence of aerosols and greenhouse gases will alter the radiative heating and cooling rates in these models and also the amount of clouds. In most of the models the representation of the biosphere (i.e. vegetation) is rather poor. The vegetation types are prescribed in each of the boxes and do not change when the climate changes.

The oceans are also represented by a large number of small boxes. The typical dimensions of each box are 200 kilometres in longitude, 200 kilometers in latitude and 1 kilometre in depth. The temperature and winds in each box are calculated using the physical laws governing the conservation of mass, momentum and energy in the oceans. The salinity content of the ocean is calculated by ensuring the conservation of salt. The oceans have large thermal inertia and hence change much more slowly than the atmosphere. Therefore, coupled ocean-atmosphere models must take into account the different response times of ocean and atmosphere. Most predictions about the evolution of future climate have been based on simulations with coupled ocean-atmosphere models (see Climate Change 2001).

Future Climate

The amount of carbon dioxide in the atmosphere is expected to increase further during the 21st century. The amount of increase depends upon the rate of increase of our population and the pace of industrialization in the developing countries. The Inter-governmental Panel on Climate Change (IPCC) has estimated that the amount of carbon dioxide in the atmosphere will be in the range of 500 to 900 ppm at the end of the 21st century. The amount of methane in the atmosphere at the end of the 21st century is expected to be in the range of 1.5 to 3.7 ppm. Although the amount of methane in the atmosphere is much less than the amount of carbon dioxide, it has a greater impact on climate. This is because the amount of terrestrial radiation absorbed by a molecule of methane is 21 times more than that absorbed by a molecule of carbon dioxide.

Predictions by climate models indicate that the global mean temperature may be 1.5 to 5.5° C above the present value at the end of the 21st century. Why is the range of predicted temperatures so large? There are two reasons. The first is on account of the uncertainty regarding the level of carbon dioxide and methane that will prevail in the atmosphere at the end of the 21st century. This uncertainty is related to variations in the projections of population and the level of industrialization at the end of the 21st century. The second is on account of differences

between different climate models regarding the way they incorporate clouds, vegetation and oceanic processes. If the temperature rise at the end of the 21st century is around 1.5°C then human beings may be able to adapt to this warming. If the temperature change is around 5.5°C then it may have a catastrophic impact on weather, agriculture and health. In a warmer earth the hydrological cycle will be more vigorous and hence floods and cyclones will be more intense. The direct impact of increase in global mean temperature will be an increase in global mean sea level on account of thermal expansion of sea water and melting of ice and glaciers over land. By the end of the 21st century the global mean sea level may increase by 11 cm to 77 cm. Many low-lying areas in countries such as Maldives, Egypt and Bangladesh will be uninhabitable if the mean sea level rises by more than 50 cm. A large rise in mean sea level will also have an impact on availability of fresh water, on fisheries and tourism.

Soot and Climate

In the past few years a new concern has been expressed about the impact of soot aerosols on climate. Soot is present in the atmosphere in many regions of the world where there is fossil fuel or biomass burning. Soot aerosols in these regions absorb strongly. Hence they warm the lower troposphere and cool the surface. In the Arabian sea and the Indian ocean, soot aerosols were found during the period January to April during the Indian ocean experiment (see Satheesh and Ramanathan 2000). In this season the soot aerosols generated by fossil fuel and biomass burning in the Indian sub-continent reaches the Arabian sea and the Indian ocean on account of the prevailing north-easterly winds. The prevailing winds change direction in May. As the winds increase in May and June, natural aerosols become more important in the Arabian sea and the Indian ocean. The amount of natural aerosols (such as sea salt and dust) that is generated depends on the wind speed. During the south-west monsoon season the winds are large and hence natural aerosols become more important than the aerosols generated by human activities. Aerosols such as sulfate and sea salt reflect radiation and hence cool the atmosphere and the surface of the earth. Aerosols such as soot and dust absorb solar radiation and heat the atmosphere and cool the

The oceans are also represented by a large number of small boxes. The typical dimensions of each box are 200 kilometres in longitude, 200 kilometers in latitude and 1 kilometre in depth. The temperature and winds in each box are calculated using the physical laws governing the conservation of mass, momentum and energy in the oceans. The salinity content of the ocean is calculated by ensuring the conservation of salt. The oceans have large thermal inertia and hence change much more slowly than the atmosphere. Therefore, coupled ocean-atmosphere models must take into account the different response times of ocean and atmosphere. Most predictions about the evolution of future climate have been based on simulations with coupled ocean-atmosphere models (see Climate Change 2001).

Future Climate

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surface. Hence the presence of soot will tend to heat the atmosphere while sulfate aerosol will tend to cool the atmosphere. The impact of soot aerosol on climate will be complex because it simultaneously heats the atmosphere and cools the surface. When both soot and sulfate aerosols are present, the atmosphere may be cooled or heated depending upon the relative amount of soot and sulfate.

The impact of absorbing aerosol on global climate may not be large but the impact on regional climate could be large. Most climate models have not incorporated the effect of absorbing aerosols on the radiation budget. Hence the understanding of the impact of absorbing aerosols on regional climate is still in its infancy. In the past year some studies have examined the impact of soot emission from India and China on regional climate (see Menon et al 2002). The amount of data available regarding the seasonal variation of soot in India is limited and hence these models have assumed that the amount of soot in the atmosphere is independent of season. This assumption is not realistic since the natural aerosols (such as salt) are more abundant during the May to October period than the anthropogenic aerosols (see Satheesh and Srinivasan 2002). Moreover, the impact of aerosols on climate depends upon how clouds are represented in these models. Since the representation of clouds in General Circulation Models (GCM) is still very primitive, the prediction of the impact of aerosols on regional climate by these models will not be reliable (see Srinivasan and Gadgil, 2002).

Conclusion

The climate of the earth will change in the 21st century on account of emission of greenhouse gases and aerosols by human beings. The greenhouse gases and absorbing aerosols will warm the atmosphere while the sulfate aerosols will cool the atmosphere. Hence it is difficult to predict the net impact of all these emissions. Gases such as carbon dioxide remain in the atmosphere for more than 100 years. In contrast the aerosols released by human activities remain in the atmosphere for a few weeks. Hence the impact of reduction in aerosols will be seen almost immediately

while the impact of reduction in carbon dioxide will not be seen immediately. Carbon dioxide is an invisible pollutant that does not have any direct adverse impact on our health. Hence most countries have no legislation to reduce the emission of carbon dioxide. Since the residence time of carbon dioxide is more than a hundred years, it can cause an irreversible change in global climate. The impact of carbon dioxide on human beings will be indirect. The increase in global mean temperature induced by increase in carbon dioxide will lead to higher sea levels, changes in the pattern of pest and diseases and changes in the yield of crops. These changes will be complex and not straightforward. For example, an increase in carbon dioxide alone will increase the yield of crops through better photosynthesis. An increase in carbon dioxide will increase the surface temperature and hence can increase the moisture stress. If the impact of moisture stress is dominant then there will be a decrease in yield of the crop even though more carbon dioxide is available for photosynthesis. The impact of aerosols on climate and agriculture is even more complex. Our understanding of the impact of aerosols on climate and agriculture is very primitive and hence we cannot provide a reliable estimate of the impact of aerosols at this time. The nature of the impact of aerosols will depend upon whether they are reflecting (i.e. sulfate) or absorbing (i.e. soot) and their spatial pattern. The spatial and temporal variation of aerosols is known very poorly. In contrast the spatial variation of carbon dioxide is very small and the temporal variation is well known.

As more and more human beings in developing countries demand cleaner air, the problem associated with aerosols should subside. An attempt to reduce carbon dioxide emission will not be so simple. This is because it is intimately linked to our modern energy-intensive lifestyle. People in developed countries will not give up their energy-intensive lifestyle unless they are convinced that there is an immediate threat to their health or climate. The impact of increase in carbon dioxide on climate or health will not be seen immediately but will begin to emerge in 50 to 100 years. Hence governments in developed countries will be reluctant to bring legislation to reduce the emission of carbon dioxide until the adverse impacts are discernble. If the governments wait that long,

then they may be unable to prevent an adverse irreversible change in the climate of the earth.

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SANJIV LEWIN

Health and Psychosocial Consequences of Disasters

– A Bangalore Response

"Missed opportunities and misplaced priorities have been the highlight of Disaster response." – Rajya Sabha '98

"Disasters are a shared reality...and have to be responded to with a multi-pronged approach."
– Unnikrishnan and Parasuraman 2000.

St. John's has had the unique opportunity to serve on Disaster Relief teams during numerous disasters in the sub-continent. Our first was when teams were sent to the 1971 Bangladesh War when millions crossed the border and were housed in makeshift refugee camps in West Bengal. The Bhopal Gas tragedy was yet another devastating experience for teams from Bangalore. 'The Bangalore Response' sent teams to coastal Andhra Pradesh following the 1977 cyclone. When Bangladesh reeled under a cyclone in 1991, St. John's along with the Community Health Cell and Service Civil International assisted in relief work in the areas of Kutubdia, Chittagong, Char Mothar and Bhola alongside young Bangladeshi

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Dr Sanjiv Lewin, Associate Professor–Pediatric and Clinical Ethics, Convenor, Disaster Relief and Training Unit, St. John's Medical College, Bangalore

college students. Teams also went to Khillari area of Marathwada following the 1993 earthquake and set up satellite medical camps. The super cyclone that hit Orissa in 2000 saw teams from Bangalore along with HAM operators in Paradeep, Jagatsinghpur and Ersama areas. Our latest learning experiences have been in Gujarat in 2001 following the earthquake. Following these experiences St. John's decided that it was only sensible to begin a Disaster Relief and Training Unit to utilize all these experiences to help people in need, to share in the responsibility of providing health care within our expertise and capabilities during disasters and to transfer information and expertise to other health teams who care to do the same. These became the goals of the Unit – to be prepared and to help when necessary.

Life cycles of a Disaster

In our experiences we have seen natural disasters ravage areas and after a lull disaster striks again. Disasters tend to affect most devastatingly the most vulnerable members of society – women and children. These displaced populations (refugees) then are placed in camps that tend not to rehabilitate but to provide relief, which in some cases is a new disaster. The camps become overpopulated with poor sanitation and drinking water supplies, which in turn leads to more disease and morbidity. Since preparedness isn't really our this assistance usually comes late or is unequally distributed.

Phases in a Disaster

Numerous interventions define different stages. However, most describe three or four phases. From a health point of view I will describe three phases.

- Phase I: Minutes – hours to days

  In this phase it is important to separate the dead from the living. The local community and the Armed Forces do this best. The discipline and effectiveness of the Services in these trying circustances cannot be underestimated. The priorities

are to immediately search for and rescue those buried or stranded and in need of immediate medical intervention. The decision is to separate the "dead" from the living, those in need of immediate salvageable medical interventions much like a wartime scenario. Hence it is necessary to establish local health centers and field hospitals capable of operating independently in spite of the lack of supportive infrastructure.

- Phase II: Days to a week

  This is the phase where most medical teams play a role in the immediate post - disaster scenario. The earlier the team arrives with the ability to set up camp independently, the more useful is the team. In this scenario, triage of patients occurs and facilities to intervene medically and surgically including orthopedics, becomes essential. Public health measures and preventive education begin at this stage when the camps begin to develop around areas of a disaster.

- Phase III: Weeks-months

  During these days, food, drinking water and shelter become much more important. Shelter is usually a camp and people tend to await relief measures. Rehabilitation is the word and to make it successful it is important that people are in a state of mind to accept rehabilitation and rebuild their devastated lives. This is when psychosocial consequences of loss of lives – human and animal, loss of shelter/ work places/ livelihoods and fear remain unrecognized. These consequences lead to behavior patterns typically seen in survivors of disasters and in addition make rehabilitation efforts a failure. During this period teams (e.g. NIMHANS) assess, train and sensitize local community volunteers who may not be doctors, to recognize and tackle psychosocial consequences affecting survivors of disasters. These interventions make rehabilitation more acceptable and successful in the long run.

Lessons learnt from the field

- Bangladesh 1991: A Phase III intervention because of delay in obtaining visas since Rajiv Gandhi had just died. This experience showed us both sides of the role of NGOs and the politics of aid. It becomes important to recognize NGOs and their motives to be able to perform work expected of a relief medical team.

- Latur-Khillari 1993: Teamwork and integration into the planning and implementation of disaster relief measures in health, nutrition and shelter was the lesson learnt here in Marathwada. This phase II intervention was a wonderful experience especially in terms of delivering the goods.

- Orissa 2000: Orissa was a phase I-II intervention and it showed us the importance of being prepared, planning intervention and avoiding delays in providing assistance. The importance of team morale also became an important factor with psychosocial consequences of disasters also hitting team members.

- Gujarat 2001: This intervention was rapid and within phase I-II. Unfortunately, it showed us "Disaster Tourism" at its worst! "Photogenic" teams and "band aid" relief all made us guilty of unethical behaviour seen even months after the disaster. The difference between "relief" in Orissa and Gujarat was a lesson in itself.

Epidemiology of Disasters

"Epidemiological knowledge of the causes of injuries and illnesses caused by natural disasters is clearly essential to determine relief supplies, equipment and personnel needed to respond effectively to such situations". During numerous disasters this basic fact has been forgotten. In 1976, the Guatemala earthquake found relief supplies to the extent of 90% of no value; 100 tons of unsorted, expired supplies and with unrecognizable foreign labels. Again in 1988, during the Armenian earthquake, 70% of 5000 tons of

supplies remained unutilized; 11% was useless, 8% time expired and 20% was destroyed. Any aid must be appropriate to the disaster and to survivors' needs.

The earthquake scenario

- Latur-Khillari 1993
- Gujarat 2001

Both these disasters presented scenarios different from those seen in cyclones. Earthquakes caused 28% mortality in the 1960s and approximately 50% mortality in the 1980s among those killed in natural disasters. The difference is reversed in the case of cyclones, with 57% in the 1960s and 14% in the 1980s. One explanation is the rapid urbanization of nations leading to more devastation in building collapses. In addition, cyclone damage has probably dropped because of early warning systems and disaster preparedness (e.g. cyclone shelters, wireless). "Specific medical and health problems tend to occur at different points in time following a disaster. Anticipation before these needs arise and delivering interventions at precise times and points where they are needed most these two fundamental facts would go a long way in disaster relief being more effective. In an earthquake, "a most destructive event in nature", building collapses, entrapment, loss of power and water supplies are the general rule. Therefore, health problems seen are usually classified as :

- Damage to existing health care facilities, power, water supplies
- Instantaneous death
  - Head, chest injuries
  - Haemorrhage (bleeds)
- Rapid death
  - Asphyxia
  - Hypovolemic shock (loss of blood, fluids from body)
  - Hypothermia
- Delayed death
  - Dehydration, hypo/hyperthermia

- Crush syndrome (crush injuries leading to widespread damage to tissue)
- Post-operative sepsis (surgery performed in less than ideal circumstances)

Common problems seen are minor cuts and bruises and simple fractures. Superficial head and lower limb injuries are the commonest. Also seen are multiple fractures, wound infections/ sepsis, multiple organ failure, gangrene, compartment syndrome, burns. Routine medical problems seen in daily practice tend to increase with increase in stress, exposure and environmental changes, like acute MI (heart attacks), diabetes, hypertension, anxiety and respiratory diseases (lung infections and allergies like asthma). Facts suggest that 93% survived if extracted within the first 24 hours. In fact, 95% of deaths were due to failure to extract and less than 50% of those buried were alive within the first 2-6 hours. This makes search and rescue most important in an earthquake. "If any significant reduction in earthquake mortality is to be achieved, appropriate search and rescue action within the first 2 days after impact is a must. Most demand for medical services also occurs within the first 24 hours. Most injured appear at medical camps during the first 3-5 days. An arrival after 7 days of specialized field hospitals is too late." These facts clearly outline our priorities. Once camps are formed numerous interventions are ordered and must be refrained from for they overburden any existing organization or infrastructure. One such intervention is mass vaccination campaigns against cholera and typhoid. "As in the case of most natural disasters, the risk of secondary epidemics is minimal and mass vaccination is inappropriate following earthquakes."

The Cyclone scenario

- Bangladesh 1991
- Orissa 2000

The physics of a cyclone is a rotating wind system with high-speed winds leading to a tidal wave or "storm surge". This leads

to high mortality especially in females and those in extremities of age, i.e., 0-4 years and < 70 years as described in the 1970 Bangladesh cyclone. Most died from drowning, house collapses and blunt trauma. Therefore, health problems could be classified as below :

- Damage to existing health care facilities, power, water supplies
- Instantaneous death
  - Drowning
  - House/Tree collapse
- "Cyclone syndrome"
  - Chest, Medial aspects of thighs
- Lacerations, Fractures, penetrating injuries (A.P. 177 ortho/ 10,000 dead!)
- Electrocution

Health needs are relatively simplified and do not require fully - equipped field hospitals/ surgical teams. No sophisticated surgical/ intensive care teams needed. Simple measures to be followed like wounds to be flushed copiously with saline. Primary closure (immediate suturing) should be avoided if suspicion of possible wound contamination exists.

Health Needs

In phase I of a disaster, depending on the nature of Disaster, the usual problems faced are the dead – animals, humans the trauma - related problems like fractures, head injuries, abdominal injuries, life- and limb-threatening injuries, hypothermia and shock. This makes it ideal to have the Armed Forces teams within 24 hours followed by Specialist Field Hospitals within the next 7 days. The local community becomes most important especially if prepared and trained for the following measures:

- Search and Rescue
- Separation of Dead from Living
- Ability Triage
- Transportation

- Surgical/orthopedic procedures
- Life-, limb-saving procedures
- Resuscitation.

In phase II, problems are more basic : carcasses, trauma-related injuries and the absence of shelter, food, water, sanitation and relief. The needs of the hour would be the disposal of carcasses, chlorination of water sources, shelter and clothes, food distribution, trench latrines, health education, clinics and disease surveillance.

In phase III, problems identified would be camps, infections – intestinal, respiratory and skin, exposure – heat or cold- malnutrition, vulnerable populations and psychosocial problems. The needs during this period would be prevention measures, public health measures, health education (hygiene, sanitation, safe drinking water, shelter), psychosocial assistance, re-establishing health facilities and rehabilitation of the disabled.

Epidemics

The question about epidemics keeps cropping up.

Rumours begin especially with regard to favourites like cholera, typhoid, snakebites etc. Communicable diseases caused by fecal contamination of water and respiratory diseases spread. "Overcrowding and deteriorating sanitation is the cause. Disease surveillance, appropriate sanitary and medical measures are the key. Mass vaccination is NOT indicated!"

Disposal of bodies

Disposal of bodies is a social problem rather than a major health hazard. They should be taken care of but in an order of priority. Bodies do not cause outbreaks of typhoid, cholera and plague. Bodies could contaminate water supplies and spread acute gastroenteritis / food poisoning. It is an important social problem, and fuel for cremation becomes a necessity.

Earthquakes cause many deaths and overwhelming injuries needing extensive care. Food shortages are rare and major population movements less likely. Cyclones also cause many deaths (especially if associated with floods). Few severe injuries need extensive care. Cyclones also cause food shortages and major population movements.

Health needs could be summarised as follows:

- Trauma - related: Orthopedic and surgical injuries, infections and wounds, revision surgeries – nailing, plates, fixators; rehabilitation, disability limitation – physiotherapy, prosthetics.
- Exposure - related (shelter and clothes): Acute respiratory infections, infections
- Sanitation/drinking water - related: diarrhoea, dysentery, and infections
- Psychosocial consequences: Grief, Depression, guilt, unresponsiveness, reactions
- Food supplies: Malnutrition, vitamin and mineral (e.g. iron) deficiencies
- Gender and Child Issues: Health needs, routine and specific.

Donations of Medicines

Whenever medicines are collected and sent to the field it is important to remember the following. Only WHO Essential Drug Lists are to be used. No samples are to be collected, only bulk and preferably generic medicines are to be sent to the field with legible labels. It is important to avoid perishable items (e.g. blood). Material to chlorinate water sources (safe drinking water) and other preventive measures (shelters, sanitation, food distribution), basic clinical equipment and mobile Operation Theatres/Hospitals would be ideal. It is also important that *standard medical protocols/procedures be followed.*

Local transportation is an issue. There should be an attempt to avoid duplication of resources, allowing specific- and need-based

destinations. "Disaster Tourism" is to be discouraged. Communications using HAMs, wireless, cellular phones and paramilitary communication would be needed. The media does play a role here if it is constructive. Coordination is the key. Neutral coordinators with need - based directions, which will list potential volunteers and categorize them according to skills (Doctors, Nurses, Paramedics, Laboratory, General Purpose, Communications, Transport) would be required. Teams should not be a burden on local resources. They should also be provided shelter, food, drinking water, personal medicine kits, stationery, registers, entertainment and transportation. They should be mixed teams with multiple capabilities including medical curative/ palliative services, surgical curative/ palliative services, preventive measures – chlorination, sanitation, equal distribution, education, surveillance especially of vulnerable population, disease outbreaks, feedback, periodic health reports and miscellaneous – food distribution, shelter, disposal of bodies.

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K R SETHUMADHAVAN

Hazard Assessment And Vulnerability Analysis

1.0 The objectives of this paper are

(i) To define hazard
(ii) To define vulnerability, vulnerability analysis
(iii) To list factors responsible for vulnerability
(iv) To enumerate the methodology to calculate level of vulnerability
(v) To discuss a case study.

2 Hazard Assessment

2.1 Hazard assessment concerns the properties of hazard itself (e.g. cyclone, flood, drought, earthquake etc.) and its direct effect but not its effect on socio-economic environment, which is covered by vulnerability analysis.

2.2 Hazard assessment aims to evaluate (a) the nature, severity and frequency of the hazard, (b) the area likely to be affected and (c) the time and duration of impact.

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3.0 Vulnerability and vulnerability analysis

3.1 Vulnerability is defined as "a set of prevailing or consequential conditions composed of physical, socio-economic and/or political factors which increase a community's susceptibility to calamity or which adversely affect its ability to respond to events". The quantum and intensity of these factors - physical, socio-economic, and political - prevailing in a community or village indicate the 'level of vulnerability' of that village. Identifying the level of vulnerability warrants vulnerability analysis, which is a "process, which results in an understanding of the types and levels of exposure of persons, property and the environment to the effects of identified hazards at a particular time".

4.0 List of factors

The physical and socio-economic factors responsible for the vulnerability culled out from the schedule designed for the sample study are furnished below:

1. Coastal length covered by the village
2. Length of rivers, streams, canals, saltpans passing through the village
3. Population density in the village per sq.km
4. Cattle per 100 population of the village
5. Huts per 100 population of the village
6. Mud wall houses per 100 population of the village
7. Area under paddy as a percentage of total cultivable area
8. Population engaged in agricultural activities as a percentage of total population of the village
9. Population engaged in fishing activities as a percentage of total population of the village
10. Fishing boats per 100 fishing population

The first two factors can be grouped under physical factors and the rest can be classified as socio-economic factors.

5.0 Methodology

5.1 The following two methods have been used, taking into consideration the above ten factors, to work out the 'level of exposure' or vulnerability coefficient for each village covered under the sample study.

1. RANK method
2. INDEX method

5.2 In the Rank method, sample villages are arranged in descending order for each of the factors responsible for vulnerability and are assigned rank-scores accordingly. These rank-scores of each village for each factor are summed and the villages are ranked accordingly in descending order of the total rank-scores. The total rank-scores are then converted into a scale with mean 50 and standard deviation 10 to arrive at the vulnerability coefficient for each village.

5.3 In the Index method, each factor considered to be responsible for vulnerability, is expressed as a percentage of the average of the sample villages. The index-scores of each factor for the village are aggregated and the villages are ranked in descending order of aggregation. The aggregated index-scores of each village are then converted into a scale with mean 50 and standard deviation 10 to arrive at the vulnerability coefficient for each village.

6.0 Case Study

6.1 The Disaster Management Training Centre functioning at Anna Institute of Management conducted a sample study on the villages vulnerable to cyclone and flood in the districts of Nagapattinam Quaid-E-milleth and Chengalpattu MGR (combined) selecting ten villages in each district from the

list of vulnerable villages made available by the respective district collectors. One of the objectives of the study was to work out the vulnerability coefficient

6.2 The rank-scores for each village for each factor of Nagapattinam Quaid-E-milleth and Chengalpattu MGR districts are presented in tables 1 and 2 respectively. The index values for each village covered under these districts are depicted in tables 3 and 4. Tables 5 and 6 compare rank-scores and index-scores for each factor. The conversion equation for rank-scores and index-scores into a scale with mean 50 and standard deviation 10 is detailed below:

$Vnr = 1.46R_n - 33.89$

$Vcr = 1.28R_c - 24$

$Vni = 0.02481_n + 17.56$

$Vci = 0.04921_c + 4.12$

V = vulnerability coefficient; n = Nagapattinam: c= Chengalpattu MGR; r = Rank method : i = Index method.

6.3 Grading of vulnerability has been done on the basis of the values. Villages having values less than 40 are classified or graded as 'less vulnerable', while villages having values between 40 and 60 are graded as 'more vulnerable'. Those villages having values above 60 are graded as 'highly vulnerable'.

Less vulnerable (< 40)	:	South Poigainallur, Edayanchavadi
More vulnerable (>40<60)	:	Nagapattinam, Salavankuppam Nagoor, Kanathoor Reddikuppam Vellankanni, Pulicut, Predamarampuram,

Thangaperunkulam,
Vilunthanmavadi
Aurivakkam,
Vettaikaraniruppu,
Kumaranjcheri,
Tirupoondi West

Highly vulnerable (>60) : North Poigainallur,
Ooyalikuppam, Tirupoondi
East, Soolerikadu
Pudukalpakkamkuppam

6.4 Recommendation: The vulnerability coefficient for each village in the coastal district may be calculated by collecting data as mentioned above. A one-day workshop for the officers may be held at the district headquarters of vulnerable villages to explain to them how to create the data base and fix vulnerability.

6.5 Conclusion: The vulnerability coefficient indicates intensity of vulnerability of the village. It also points out the order of priority in implementing the 'Preparedness' and 'Protection' plan among the villages vulnerable to cyclone and flood.

Reference:

1. Vulnerability analysis on the village selected for sample study. Disaster Management Training Centre, Anna Institute of Management.

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Table : 1: Rank-Scores of the Variables Considered for Vulnerability Analysis – Nagapattinam Quaid-e-Milleth District

Sl. No.	Name of the villages selected	Coastal length covered by the village, km	River+stream + canal+ saltpan passing through the village, km	Population density per sq.km	Cattle per 100 population
1	2	3	4	5	6
1	Nagapattinam	5	8	10	1
2	Ngoor	6	4	9	6
3	North Poigainallur	10	9	7	4
4	South Poigainallur	4	7	6	3
5	Vellankanni	4	6	8	5
6	Predamarampuram	4	4	1	7
7	Tirupoondi West	1	6	5	8
8	Tirupoondi East	10	2	2	10
9	Vilunthanmavadi	10	2	3	2
0	Vettaikaranirruppu	10	10	4	9

Table: 1: Rank-Scores of the Variables Considered for Vulnerability Analysis – Nagapattinam Quaid-e-Milleth District (Contd.)

Sl. No	Name of the villages selected	Huts per 100 population	Mud wall houses per 100 population	Area under paddy as % of cultivable area	Population engaged in agriculture as % of total population
1	2	7	8	9	10
1	Nagapattinam	6	7	9	1
2	Ngoor	6	7	8	2
3	North Poigainallur	2	10	3	3
4	South Poigainallur	6	10	4	5
5	Vellankanni	1	8	7	4
6	Predamarampuram	9	2	1	8
7	Tirupoondi West	3	4	10	7
8	Tirupoondi East	7	7	5	6
9	Vilunthanmavadi	10	4	6	10
10	Vettaikaranirruppu	8	2	2	9

Table 1: Rank-Scores of the Variables Considered for Vulnerability Analysis – Nagapattinam Quaid-e-Milleth District

Sl. No.	Name of the villages Selected	Population engaged in Fishing as % of total population	Fishing boats per 100 fishing population	Total Rank - scores	Rank
1	2	11	12	13	14
1	Nagapattinam	4	3	54	6
2	Ngoor	7	8	63	3
3	North Poigainallur	10	6	64	2
4	South Poigainallur	2	2	49	9
5	Vellankanni	6	4	53	7
6	Predamarampuram	9	7	52	8
7	Tirupoondi West	2	2	48	10
8	Tirupoondi East	8	10	67	1
9	Vilunthanmavadi	5	9	61	5
10	Vettaikaranirruppu	3	5	62	4

Table 2: Rank-Scores of the Variables Considered for Vulnerability Analysis – Chengalpattu MGR District

Sl. No.	Name of the villages selected	Coastal length covered by the village, km	River+stream + canal+ saltpan passing through the village, km	Population density per sq.km	Cattle per 100 population
1	2	3	4	5	6
1	Salavan Kuppam	8	3	1	9
2	Ooyali Kuppam	8	9	7	8
3	Pudukalpakkam Kuppam	8	7	3	2
4	Soolerikadu	8	7	3	2
5	Kanathoor Reddikupam	8	2	8	5
6	Pulicut	10	10	9	4
7	Thangal Perunkulam	9	8	5	6
8	Aurivakkam	3	2	4	7
9	Kumaranjcheri	3	7	6	10
10	Edayanchavadi	3	7	10	3

Table: 2: Rank-Scores of the Variables Considered for Vulnerability Analysis – Chengalpattu MGR District

Sl. No	Name of the villages selected	Huts per 100 population	Mud wall houses per 100 population	Area under paddy as % of cultivable area	Population engaged in agriculture as % of total population
1	**2**	**7**	**8**	**9**	**10**
1	Salavan Kuppam	7	7	2	7
2	Ooyali Kuppam	4	5	4	10
3	Pudukalpakkam Kuppam	10	8	6	9
4	Soolerikadu	2	10	6	6
5	Kanathoor Reddikuppam	1	9	3	3
6	Pulicut	3	5	1	1
7	Thangal Perunkulam	8	2	7	2
8	Aurivakkam	9	7	8	5
9	Kumaranjcheri	5	5	10	8
10	Edayanchavadi	6	2	9	4

Table: 2: Rank-Scores of the Variables Considered for Vulnerability Analysis – Chengalpattu MGR District

Sl. No.	Name of the villages selected	Population engaged in fishing as % of total population	Fishing boats per 100 fishing population	Total Rank - scores	Rank
1	**2**	**11**	**12**	**13**	**14**
1	Salavan Kuppam	3	5	52	8
2	Ooyali Kuppam	10	4	69	2
3	Pudukalpakkam Kuppam	9	9	71	1
4	Soolerikadu	7	7	58	5
5	Kanathoor Reddikuppam	4	6	49	9
6	Pulicut	8	10	61	3
7	Thangal Perunkulam	6	8	61	3
8	Aurivakkam	5	3	53	7
9	Kumaranjcheri	2	2	58	5
10	Edayanchavadi	2	2	48	10

Table 3 : Index-Scores of the Variables Considered for Vulnerability Analysis – Nagapattinam Quaid –e-Milleth District

Sl. No.	Name of the villages selected	Coastal length covered by the village, km	River+stream + canal+ saltpan passing through the village, km	Population density per sq.km	Cattle per 100 population
1	2	3	4	5	6
1	Nagapattinam	96	167	310	20
2	Ngoor	110	42	176	120
3	North Poigainallur	137	250	61	80
4	South Poigainallur	82	83	54	70
5	Vellankanni	82	63	101	90
6	Predamarampuram	82	42	26	130
7	Tirupoondi West	0	63	44	180
8	Tirupoondi East	137	0	26	800
9	Vilunthanmavadi	137	0	29	60
10	Vettaikaranirruppu	137	292	41	380

Table 3: Index-Scores of the Variables Considered for Vulnerability Analysis – Nagapattinam Quaid-e-Milleth District

Sl. No	Name of the villages selected	Huts per 100 population	Mudwall Houses per 100 population	Area under paddy as % of cultivable area	Population engaged in agriculture as % of total population
1	**2**	**7**	**8**	**9**	**10**
1	Nagapattinam	100	100	276	6
2	Ngoor	100	100	264	65
3	North Poigainallur	40	200	59	102
4	South Poigainallur	100	200	69	183
5	Vellankanni	27	150	133	131
6	Predamarampuram	147	0	8	296
7	Tirupoondi West	67	50	366	291
8	Tirupoondi East	127	100	79	210
9	Vilunthanmavadi	220	50	99	657
10	Vettaikaranirruppu	133	0	34	502

Table 3: Index - Scores of the Variables Considered for Vulnerability Analysis – Nagapattinam Quaid-E-Milleth District (Cond.)

Sl. No.	Name of the villages selected	Population engaged in fishing as % of total population	Fishing boats per 100 fishing population	Total Rank scores	Rank
1	2	11	12	13	14
1	Nagapattinam	38	29	1142	6
2	Ngoor	86	114	1177	5
3	North Poigainallur	786	104	1819	2
4	South Poigainallur	0	0	841	10
5	Vellankanni	68	64	909	9
6	Predamarampuram	177	107	1015	8
7	Tirupoondi West	0	0	1061	7
8	Tirupoondi East	115	429	2023	1
9	Vilunthanmavadi	53	179	1484	4
10	Vettaikaranirruppu	2	89	1610	3

Table 4: Index-Scores of the Variables Considered for Vulnerability Analysis – Chengalpattu MGR District

Sl. No.	Name of the villages selected	Coastal length covered by the village, km	River+stream+canal+saltpan passing through the village, km	Population density per sq.km	Cattle per 100 population
1	2	3	4	5	6
1	Salavan Kuppam	82	51	26	367
2	Ooyali Kuppam	82	171	105	173
3	Pudukalpakkam Kuppam	82	68	29	0
4	Soolerikadu	82	68	29	0
5	Kanathoor Reddikuppam	82	34	105	73
6	Pulicut	185	334	184	60
7	Thangal Perunkulam	103	102	41	120
8	Aurivakkam	0	34	40	167
9	Kumaranjcheri	0	68	50	407
10	Edayanchavadi	0	68	292	33

Table 4: Index-Scores of the Variables Considered for Vulnerability Analysis – Chengalpattu MGR District

Sl. No	Name of the villages selected	Huts per 100 population	Mud wall houses per 100 population	Area under paddy as % of cultivable area	Population engaged in agriculture as % of total population
1	2	7	8	9	10
1	Salavan Kuppam	157	100	46	138
2	Ooyali Kuppam	71	50	97	361
3	Pudukalpakkam Kuppam	286	250	104	192
4	Soolerikadu	43	700	104	108
5	Kanathoor Reddikuppam	14	550	51	52
6	Pulicut	57	50	0	33
7	Thangal Perunkulam	229	0	121	39
8	Aurivakkam	257	100	135	106
9	Kumaranjcheri	129	50	239	157
10	Edayanchavadi	143	0	141	73

Table 4: Index-Scores of the Variables Considered for Vulnerability Analysis – Chengalpattu MGR District

Sl. No.	Name of the villages selected	Population engaged in fishing as % of total population	Fishing boats per 100 fishing population	Total Rank - scores	Rank
1	2	11	12	13	14
1	Salavan Kuppam	52	44	1063	7
2	Ooyali Kuppam	315	32	1457	1
3	Pudukalpakkam Kuppam	145	72	1229	3
4	Soolerikadu	110	52	1298	2
5	Kanathoor Reddikuppam	73	45	1081	6
6	Pulicut	138	128	1170	4
7	Thangal Perunkulam	96	56	907	9
8	Aurivakkam	77	31	948	8
9	Kumaranjcheri	0	0	1100	5
10	Edayanchavadi	0	0	751	10

Table 5: Comparision between Rank-Scores and Index-Scores under each Factor –Nagapattinam Quaid-E-Milleth District

Sl. No.	Name of the villages selected	Coastal length covered by the village, km		River+stream+canal+ saltpan passing through the village, km		Population density per sq.km		Cattle per 100 population	
		Scores		Scores		Scores		Scores	
		Rank	Index	Rank	Index	Rank	Index	Rank	Index
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Nagapattinam	5	96	8	167	10	310	1	20
2	Ngoor	6	110	4	42	9	176	6	120
3	North Poigainallur	10	137	9	250	7	61	4	80
4	South Poigainallur	4	82	7	83	6	54	3	70
5	Vellankanni	4	82	6	63	8	101	5	90
6	Predamarampuram	4	82	4	42	1	26	7	130
7	Tirupoondi West	1	0	6	63	5	44	8	180
8	Tirupoondi East	10	137	2	0	2	26	10	800
9	Vilunthanmavadi	10	137	2	0	3	29	2	60
10	Vettaikaranirruppu	10	137	10	292	4	41	9	380

Table 5: Comparision between Rank-Scores and Index-Scores under each Factor- Nagapattinam Quaid-e-Milleth District (Contd.)

Sl. No.	Name of the villages selected	Huts per 100 population		Mud wall houses per 100 population		Area under paddy as % of cultivable area		Population engaged in agriculture as % of total population	
		Scores		Scores		Scores		Scores	
		Rank	Index	Rank	Index	Rank	Index	Rank	Index
1	**2**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	Nagapattinam	6	100	7	100	9	276	1	6
2	Ngoor	6	100	7	100	8	264	2	65
3	North Poigainallur	2	40	10	200	3	59	3	102
4	South Poigainallur	6	100	10	200	4	69	5	183
5	Vellankanni	1	27	8	150	7	133	4	131
6	Predamarampuram	9	147	2	0	1	8	8	296
7	Tirupoondi West	3	67	4	50	10	366	7	291
8	Tirupoondi East	7	127	7	100	5	79	6	210
9	Vilunthanmavadi	10	220	4	50	6	99	10	657
10	Vettaikaranirruppu	8	133	2	0	2	34	9	502

Table 5: Comparision between Rank-Scores and Index-Scores under each Factor – Nagapattinam Quaid-e-Milleth District (Contd.)

Sl. No.	Name of the villages selected	Population engaged in fishing as % of total		Fishing boats per 100 fishing population		Total scores		Rank	
		Scores		Scores		Scores		Scores	
		Rank	Index	Rank	Index	Rank	Index	Rank	Index
1	**2**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
1	Nagapattinam	4	38	3	29	54	1142	6	6
2	Ngoor	7	86	8	114	63	1177	3	5
3	North Poigainallur	10	786	6	104	64	1819	2	2
4	South Poigainallur	2	0	2	0	49	841	9	10
5	Vellankanni	6	68	4	64	53	909	7	9
6	Predamarampuram	9	177	7	107	52	1015	8	8
7	Tirupoondi West	2	0	2	0	48	1061	10	7
8	Tirupoondi East	8	115	10	429	67	2023	1	1
9	Vilunthanmavadi	5	53	9	179	61	1484	5	4
10	Vettaikaranirruppu	3	2	5	89	62	1610	4	3

Table : 6: Comparision between Rank-Scores and Index-Scores under each Factor – Chengalpattu MGR District

Sl. No.	Name of the villages selected	Coastal length covered by the village, km		River+stream+canal+ saltpan passing through the village, km		Population density per sq.km		Cattle per 100 population	
		Scores		Scores		Scores		Scores	
		Rank	Index	Rank	Index	Rank	Index	Rank	Index
1	2	3	4	5	6	7	8	9	10
1	Salavan Kuppam	8	82	3	51	1	26	9	367
2	Ooyali Kuppam	8	82	9	171	7	105	8	173
3	Pudukalpakkam Kuppam	8	82	7	68	3	29	2	0
4	Soolerikadu	8	82	7	68	3	29	2	0
5	Kanathoor Reddikuppam	8	82	2	34	8	105	5	73
6	Pulicut	10	185	10	334	9	184	4	60
7	Thangal Perunkulam	9	103	8	102	5	41	6	120
8	Aurivakkam	3	0	2	34	4	40	7	167
9	Kumaranjcheri	3	0	7	68	6	50	10	407
10	Edayanchavadi	3	0	7	68	10	292	3	33

Table 6: Comparision between Rank-Scores and Index-Scores under each Factor – Chengalpattu MGR District (Contd.)

Sl. No.	Name of the villages selected	Huts per 100 population		Mud wall houses per 100 population		Area under paddy as % of cultivable area		Population engaged in agriculture as % of total population	
		Scores		Scores		Scores		Scores	
		Rank	Index	Rank	Index	Rank	Index	Rank	Index
1	2	11	12	13	14	15	16	17	18
1	Salavan Kuppam	7	157	7	100	2	46	7	138
2	Ooyali Kuppam	4	71	5	50	4	97	10	361
3	Pudukalpakkam Kuppam	10	286	8	250	6	104	9	192
4	Soolerikadu	2	43	10	700	6	104	6	108
5	Kanathoor Reddikuppam	1	14	9	550	3	51	3	52
6	Pulicut	3	57	5	50	1	0	1	33
7	Thangal Perunkulam	8	229	2	0	7	121	2	39
8	Aurivakkam	9	257	7	100	8	135	5	106
9	Kumaranjcheri	5	129	5	50	10	239	8	157
10	Edayanchavadi	6	143	2	0	9	141	4	73

Table 6: Comparision between Rank-Scores and Index-Scores under each Factor – Chengalpattu MGR District (Contd.)

Sl. No.	Name of the villages selected	Population engaged in fishing as % of total		Fishing boats per 100 fishing population		Total scores		Rank	
		Scores		Scores		Scores		Scores	
		Rank	Index	Rank	Index	Rank	Index	Rank	Index
1	2	19	20	21	22	23	24	25	26
1	Salavan Kuppam	3	52	5	44	52	1063	8	
2	Ooyali Kuppam	10	315	4	32	69	1457	2	1
3	Pudukalpakkam Kuppam	9	145	9	72	71	1229	1	3
4	Soolerikadu	7	110	7	52	58	1298	5	2
5	Kanathoor Reddikuppam	4	73	6	45	49	1081	9	6
6	Pulicut	8	138	10	128	61	1170	3	4
7	Thangal Perunkulam	6	96	8	56	61	907	3	9
8	Aurivakkam	5	77	3	31	53	948	7	8
9	Kumaranjcheri	2	0	2	0	58	1100	5	5
10	Edayanchavadi	2	0	2	0	48	751	10	10

Table 7: Vulnerability Coefficent

Sl. No.	Name of the villages selected	Method	
		Rank	Index
1	2	3	4
1	Nagapattinam	45	46
2	Ngoor	58	47
3	North Poigainallur	60	63
4	South Poigainallur	38	38
5	Vellankanni	43	40
6	Predamarampuram	42	43
7	Tirupoondi West	36	44
8	Tirupoondi East	64	68
9	Vilunthanmavadi	55	54
10	Vettaikaranirruppu	57	57
11	Salavan Kuppum	42	48
12	Ooyali Kuppam	64	68
13	Pudukalpakkam Kuppam	67	56
14	Soolerikadu	50	60
15	Kanathoor Reddikuppam	39	49
16	Pulicut	54	53
17	Thangal Perunkulm	54	41
18	Aurivakkam	44	43
19	Kumaranjcheri	50	50
20	Edayanchavadi	37	33

VINOD K GAUR

Disaster Mitigation

Abstract

The paper underlines the increasing vulnerability of a fast growing population in developing countries, to natural hazards. It calls attention to the overwhelming desirability of establishing effective disaster mitigation systems by taking advantage of the now globally available knowledge and information systems that have proved to be of great avail in saving human lives, if not property, in developed countries. The key element in the highly distributed endeavour of disaster mitigation which must be appropriately designed to profit by the opportunities available in the different future time windows, is the assessment of risk. Modern space-based and information technology systems open up many fruitful avenues to evaluate risk. Finally, it is urged that a Disaster Mitigation Act be legislated by Parliament to provide an overarching

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framework of policy, institutions and executive agencies to provide the right focus to the diverse elements of disaster mitigation activities, and thus create a unity of purpose among the various agencies entrusted with this responsibility.

Introduction

Natural hazards take an increasingly heavy toll of life and property with every passing year, leaving a much larger number homeless and destitute. The most grievous losses inflicted by such disastrous natural events, that is, of human lives, now take place in the developing world where several factors combine to expose an ever increasing number to grave environmental risks. Firstly, our galloping population constantly strains the available habitats, degrading their capacity for sustaining natural hazards, and drives unwary communities to occupy potentially hazardous areas, notably, low-lying flood plains and coastal tracts, steeper slopes and urban margins. In particular, the unabated rush to urban areas, which today in developing countries register the highest rate of growth (fig. 1), completely overwhelms any planned activity in rational land use, or in the siting, design and construction of buildings and lifelines. The resulting haphazard growth of high-density agglomerations with their hastily erected dwellings and virtually no infrastructure, thus makes them sitting ducks even to a random low intensity hit by earthquakes, landslides, floods or cyclones. Secondly, the near total absence of usable knowledge regarding the occurrence and magnitude of an adverse natural hazard has delayed rational assessment of hazard magnitude and risk, which provides the focus for defining disaster mitigation goals and designing appropriate strategies and the organizational set-up for accomplishing these.

The magnitude of a disaster, i.e. the value of all losses inflicted by an adverse natural phenomenon as well as of those suffered in its aftermath, is an actual realization of a possible risk scenario. Risk representing the value of all potential losses that may be caused by a hazardous event is, in turn, predicated on the magnitude of the event on the one hand, and by our ability or

otherwise to cope with its impact, that is, vulnerability, on the other. The logical and most optimistic goal of disaster mitigation is therefore risk reduction. Quantitative assessment of risk provides a rational basis for risk reduction, and thereby holds the promise of reorienting current strategies prevalent in this country so as to shift the focus from the highly expensive post-disaster rescue and relief operations to cost-effective planned action aimed at creating knowledge-based hazard-resilient public assets.

Risk assessment, as alluded to earlier, requires a knowledge of two entities: a) the expected level of hazard in an area, and b) vulnerability to its possible adverse impacts. It is defined as the generalized product of hazard and vulnerability in respect of all elements at risk: life, property, socio-economic activities and lifelines. Natural hazards essentially represent extreme fluctuations in the average dynamic state of the earth environment, notably, ground motion (earthquakes), slope stability (landslides), atmospheric temperature, pressure, precipitation (storms, floods, drought, sea level), magnetosphere (space weather) etc. Modern usage of the term, hazard, stresses quantification, signifying the probability (H), with which a given value (I) of departure from the average state, at a location (X), will not be exceeded over a future time window (t). Accordingly, hazard is symbolically represented as H (X,I,t).

However, occasional extreme departures from the average state, which in the case of the earth system constitute a natural hazard, are now understood to be a piece of the intrinsic dynamic behaviour of large composite systems. They are, therefore, just the other face of a vibrant, living planet which, alone amongst the four terrestrial planets that began their evolutionary journey with about the same genetic material (elemental distribution), finally evolved into a self-organized system of rock, water and air capable of bringing forth and sustaining a living world. Natural hazards are therefore, going to be with us forever but disasters need not. For, considerable knowledge is now available about the space-time distribution of earthquakes, floods, droughts and cyclones to enable us to make a probabilistic estimate of their expected occurrence and magnitude over a given time window in

the future. These estimates, by providing the context for analysing vulnerabilities, in turn make it possible to delineate decision options for retrofitting and other remedial measures to reduce vulnerability.

Indeed, there is enough knowledge available today to significantly reduce the risks posed by natural hazards and thereby minimize their disastrous impact. In the developed world considerable headway has already been made toward ensuring minimum risk to life, if not property, from earthquakes, floods and cyclones. For example, a magnitude 7 earthquake that rocked California in 1988 caused fewer than 10 deaths. Another example is of the 1993 Mississippi flood which took a toll of 30 lives. By contrast, the 6.3 magnitude Maharashtra earthquake of 1993 killed over 10,000 people and the 1988 floods in Bangladesh caused over 1400 deaths. The above comparisons, quite typical of the prevailing situation in developing countries, call attention to the high levels of risk obtaining even in environments of comparatively lower grade hazard. At the same time they also highlight the opportunities available today for effectively reducing the current high levels of risk in the Third world by a systematic programme to reduce vulnerability. Risk assessment therefore lies at the heart of this endeavour whence planned actions could follow logically.

Risk Reduction

Risk mitigation is a complex process whose success depends on the hazard consciousness of the communities involved and on the quality of knowledge, expertise and organization brought to bear on its execution. In particular, the various elements of the endeavour need to be carefully designed so as to address sensible issues according to the opportunities available in the different time windows of the future - long, intermediate, and short - yet telescoped to achieve the desired focus at any given time.

Specifically, two phases are identified for defining disaster mitigation goals, one before the event and the other in its

immediate aftermath and after. The first phase tasks which may be collectively called advance planning consist of a) creating knowledge-based hazard consciousness at all levels to foster i) hazard-resilient land use, siting and construction practices and ii) supportive socio-economic systems such as insurance agencies, and educational and awareness programmes, and b) preparations to cope with an imminent hazard by i) constant reassessment of hazard and vulnerability, particularly of critical facilities, and delineation of those to be retrofitted, ii) setting up possible early forecast and warning systems, iii) organization of a well coordinated executive agency to draw up detailed emergency plans, equiping it with a reliable information system for continually monitoring new developments and for decision-making, storing adequate supplies of critical materials, laying down procedures for communication and command, arranging regular hazard awareness and disaster training exercises.

In the immediate aftermath of a disastrous event, risk reduction calls for a quick delineation of all salvageable life and support systems that may be at risk, for providing timely succour through prompt appropriate action: search and rescue, evacuation, medical assistance, food and shelter, public order and coordination of relief operations. Near real-time information from space-based surveillance systems and modern computer simulation are already available to produce a first order picture of the scale of disaster and the spatial distribution of damage. These information tools can be used with great advantage to direct timely and more efficient rescue and relief operations that would minimize potential risks.

Finally, in the post-disaster phase of rehabilitation, risk maps and figures would again be required to provide the basic directions for planning reconstruction, and involving insurance agencies which cushion economic hardships by spreading costs even as they foster hazard consciousness at the individual level and provide a rational basis for the allocation of relief grants.

Risk Assessment

Risk maps and figures constitute a basic input in the decision-making process at various stages of the risk or disaster mitigation activities. As stated earlier, risk evaluation in a region or site involves the convolution of hazard which is expressed by the exceedance probabilities of various levels of hazardous environmental perturbations, with vulnerability or the damage potential of various facilities like buildings and lifelines. In this process, we obtain a maximum estimate of losses (risk) that may possibly accrue in the wake of a hazardous event. Accordingly, risk evaluation in a designated region involves the following three steps:

- **Evaluation of hazard** H (X, t, I):

  This is expressed in terms of the spatial distribution of exceedance probabilities for a specified level of environmental disturbance (ground motion, atmospheric temperature, pressure, precipitation, wind velocities) over given future time epochs. It will therefore consist of a suite of maps for different disturbance thresholds (I) and future time windows (t). A sample of one such map for ground acceleration threshold of 0.2 g for a time window of 100 years brought out by the US Geological Survey is shown in fig 2.

  The basic knowledge elements needed for this exercise are: an understanding of the physics of hazard generation, their space-time history generally and of the immediate past epochs in particular, and details of the current process if possible. In the case of cyclones, radar tracking stations along the Indian coast provide temporally evolving information on the location of the storm centre, the radius of the surrounding inner ring of calm winds, an estimate of the pressure deficit and wind velocity, which enable one to forecast the evolution and peaking of storm surges. Modern developments in SAR (Synthetic Aperture Radar) interferometry, similarly, provide valuable information on evolution of landslides and slip rates

on earthquake-generating faults (fig.3) that can now be used to periodically reassess the hazard probability in the period prior to an imminent earthquake. Correspondingly, risk evaluation, too will need to be carried out for different lengths of future time windows to suit specific purposes.

The computational approaches to preparation of hazard maps involve the following steps:

a) delineation of the sources of hazard perceived to be sources of possible threats and their characterization (space-time, dimensions, estimated probabilities of occurrence and magnitudes),

b) analytical or empirical computation of the time histories of environmental disturbances, in the event of any of these actually occurring, using available models, and

c) statistical estimation of these perturbations.

Maps of hazard available at any point of time provide the basic estimates for guiding the design of hazard resilient building codes and typologies that would not be vulnerable to the indicated level of hazard in a given environment. They also provide the measure whereby to assess the vulnerability of existing structures and systems, which in turn, helps delineate those that may be in need of retrofitting, or the design of new desirable ones.

Preparation of vulnerability V (X, t, I) maps

The second step in risk evaluation is to prepare vulnerability maps of designated areas for specified levels of hazard. This is a much more involved task requiring detailed information on topography, land use, geotechnical characterestics of the ground and engineering characteristics of buildings and infrastructure facilities. In recent years, some efforts have been made in this country to prepare a vulnerability atlas under the aegis of the Ministry of Urban Development, using

census data as a proxy index of vulnerability. Many other such proxy indicators could be integrated through a GIS to refine this task. Vulnerability of an area and its community to natural hazards is a dynamic entity, weighted by the quality of the human habitat and works at the time. It decreases with improved design and construction practices and with more reliable infrastructure and communication facilities. Conversely, vulnerability increases in areas of unplanned growth of human habitations and social and economic activities, unmindful of the lurking threat of natural hazards. For, it encourages ad hoc siting and unsafe construction activities which at the same time choke access routes and degrade lifelines.

Vulnerability assessment therefore requires a very careful synthesis of a large number of factors: topography, slopes, geotechnical properties of the ground, engineering characteristics of structures, and of lifeline systems. Fortunately, the availability of modem Geographical Information Systems (GIS), capable of assembling, storing, manipulating and displaying geographically referenced information, now makes it possible to attempt such a synthesis and test the validity of alternative schemes. Several of these factors can now be abstracted from space imageries, duly validated by a few ground checks, to progressively enhance the realism of vulnerability maps. For example, topographic data from the Shuttle Radar Topographic Mission, 1999, will shortly be available at 90 m resolution in the public domain. These, together with those of Synthetic Aperture Radar (SAR) and visible and infra-red imageries from the European ERS and the Indian IRS, can be used to abstract higher level information, notably topographic slopes (fig. 4), radar echo amplitudes for possible mapping of liquefaction prone areas, infra-red and night time luminosities (fig. 5) as proxy indicators of habitation density and socioeconomic activities. The basic GIS can thus be progressively enriched to construct and test realistic models of vulnerability.

- **Risk** maps/figures:

  Finally, a suite of Risk maps/figures for a designated area or site can be generated by combining the hazard and vulnerability maps in an appropriate manner that would eventually reduce to obtaining weighted sums of the hazard with different aspects of vulnerability, foremost amongst which, in the context of a relatively low technology society such as ours, will be the engineering characteristics of dwellings and of critical facilities. Although we are not aware of any systematic activity for regional risk evaluation, risk assessment and audit are a normal feature of most utilities in advanced countries, and there is considerable information now available as to how to quantify risk as well as computational tools to accomplish it. There are, therefore, no insuperable problems in attempting to evaluate risk in a given context, and the quality of the products will progressively improve as more and more experience is gained in actually performing this task.

Effective Public Participation:

Despite grave risks to large parts of the country from natural hazards, environmental safety has not emerged as an important agenda for the public, administrators, politicians, and government, perhaps because disasters caused by natural hazards are regarded as an unavoidable part of life. This adversely affects any systematic long-term initiative on risk evaluation and mitigation. It is therefore important that risk evaluation and mitigation work should be made more broad-based, and active participation by the public generally and by NGO's and other sections of society, consciously integrated in this endeavour. However, much more needs to be done on this front by different Government agencies in a systematic manner. All concerned agencies need to be induced to design their own plans directed towards the common goal of risk mitigation. For instance, the Bureau of Indian Standards could be encouraged to publish its relevant codes for

earthquake- resistant constructions in local languages, and to bring out commentaries and handbooks to enable easy interpretation of seismic codes.

Participation of the Insurance Sector and Other Financial Institutions in Disaster Mitigation

Financial institutions (e.g. ICICI, IDBI, HUDCO) and the insurance sector play a very important role in risk evaluation and mitigation. Financial incentives such as realistic insurance premia reflecting the vulnerability of different structures act as a motivating factor to encourage rational design and good construction practices. Safety clearance should, therefore, be made mandatory for important and critical structures before according them financial clearance. The Tariff Advisory Committee of the insurance sector must assist the insurance companies in developing rational insurance policies. The insurance companies could also act as an effective agent to sensitize communities to the desirability of adopting safe siting and construction practices. Together with Government grants and financial institutions, they may also help evolve a rational mechanism for the allocation of relief grants linked to insurance. This will instil greater hazard-consciousness at individual levels and encourage private initiative in reducing vulnerability and risk, which the dole culture will not. Creative socio-economic measures to reduce vulnerability, such as this, as well as others to address the issues listed in this chapter, could be effectively implemented at various levels, if a national body empowered by an Act of legislature, as suggested below, were to be in place.

An overarching framework of Policy, Institutions and Executive Agencies

Disaster mitigation or risk reduction will always remain a highly distributed activity, consisting of a great diversity of scientific, engineering, administrative, financial, and social processes. Since

they are intended to serve a common purpose, they need to be consciously structured to achieve a unity of purpose. This, in turn, calls for the presence of an overarching framework of Policy, Institutions and a hierarchy of Executive Agencies from the national to local levels.

A directive force of this nature is best provided by a clear, resolute, undiluted and indivisible charge vested by an Act of Parliament. It is accordingly felt that the enactment of a national Disaster Mitigation Act by the Indian Parliament, incorporating the requisite Policy and Institutional framework will impart the right focus, strength and urgency for this gravely urgent national responsibility even as we approach the close of IDNDR, the International Decade of Natural Disaster Reduction.

B RAMAN

Internal Security: Changing Environment

Amongst the factors which contribute to threats to the internal security of a nation are:

- Bad governance marked by incompetence, inefficiency, economic mismanagement, lack of adequate attention to economic and social development, feelings of economic and social injustice in large sections of the people, corruption and the insensitivity of the administration to the legitimate grievances of the people and the consequent absence of a well-functioning mechanism for redressal of the grievances of the people. The feeling amongst large sections of the people that they are governed by a leadership or administration that does not care sows the seeds of alienation leading to challenges, which may be peaceful initially, but tend to degenerate into violation of law and order and the authority of the State.

- A failure on the part of the aggrieved sections of the people to understand and accept that there are limits to

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what a leadership or administration can do to meet their grievances, that even in the best governed State there will always be unfulfilled expectations and that while it would be legitimate to continue to articulate such unfulfilled expectations, resort to agitational methods, particularly involving violence, could weaken the fabric of the State and the administration.

- A failure of the political leadership, the State and the administration to be sensitive to the grievances of the minorities, whether ethnic or religious, and to protect their lives, interests and property, and the consequent emergence of feelings of alienation.

- A lack of moral integrity in the political leadership and administration marked by corruption, nepotism, abuse of authority, tolerance of wrong-doings, criminalisation of politics and the failure to enforce the law, either due to timidity or due to a nexus with the law-breakers, which weakens the credibility of the State and the administration in the eyes of large sections of the people. A State or administration which does not enjoy the respect of the governed cannot enforce the rule of law effectively.

- The absence of statesmanship, the ascendency of partisan political interests over national interests and unprincipled and opportunistic politics, with the political parties ever on the lookout for opportunities and grievances amongst the people, even illegitimate, which they can exploit without consideration of the impact that such exploitation may have on the rule of law. The political landscape is consequently marked by a plethora of politicians, but hardly a statesman.

- The exploitation of the grievances and the feeling of alienation among certain sections of the people by external powers for achieving their strategic objectives.

- The absence of effective national security management, whether internal or external, characterised by an unsatisfactory intelligence and physical security apparatus and a political leadership, whether in the ruling circles or in the opposition, so engrossed with the politics of the politicians and not of statesmen, that it has neither the time nor the inclination to attend to removing the systemic deficiencies.

2. Since Independence and, more particularly, during the last 30 years, India has been a victim of all these evils. The result: the festering ethnic or tribal insurgencies in the North-East; the continuing Marxist insurgencies of various hues in different States; the periodic outbreaks of communal tension and violent disturbances; ideologically- and religiously-oriented terrorism in different parts of the country, particularly in Jammu & Kashmir (J&K); the mushrooming of organised crime groups, national and transnational, and their nexus with politicians on the one side and with the terrorists on the other; and the exploitation of the resulting situation by Pakistan and its Inter-Services Intelligence (ISI) to wage a proxy war against India to keep the Indian Security Forces and the civilian population bleeding. The ultimate Pakistani objective is not just the annexation of J&K as it is often projected to be by many analysts, but to permanently weaken the fabric of the Indian State and national unity and create a mental divide between the Hindus and the Muslims, hoping and calculating that such a mental divide would ultimately lead to a further territorial division of the nation.

3. The internal security landscape has been further darkened by the appearance on the scene since 1993 of the Pakistan-based pan-Islamic warriors, many guided and orchestrated by the State of Pakistan and its military-intelligence establishment, but an increasing number, since 1998, by the Osama bin Laden-led International Islamic Front for Jehad (Crusade) against the US and Israel. The threats from State and non-State actors across our borders with Pakistan and

Bangladesh have blurred any distinction between internal and external security. The threats to internal security increasingly arise from external actors, who have been able to exploit our tardiness and ineffectiveness in addressing the causes of the domestic threats.

4. If the Maoists of Nepal, who look upon the Indian State as an adversary, and the L TTE of Sri Lanka, which continues to be one of the most ruthless terrorist organisations of the world, succeed in coming to power, the impact on our internal security situation could be negative and could aggravate the problems faced by the national security apparatus. If bin Laden's International Islamic Front succeeds in its "Look East" policy of spreading its virus to the Muslim populations of Bangladesh, the Arakan State of Myanmar, southern Thailand, Singapore, Malaysia, Indonesia and southern Philippines, India would find itself buffeted by pan-Islamic ill-winds blowing from the West as well as the East. The effects of this ill-wind would be particularly felt in South India, hitherto largely unaffected by pan-Islamic ideas, because of the presence of a large number of Muslim migrants of Indian origin in South-East Asia and their continuing blood and mental links with their kith and kin still living in India.

5. Is there an adequate awareness in the central and state leaderships of the new dimensions of the threats to our internal security? Do we have a carefully worked-out short,- medium-, and long-term strategy to deal with these threats politically, ideologically, economically, socially and systemically? Do we have a national security apparatus capable of implementing the strategy effectively and do we have a political leadership in the Centre and the States, which would back, consistently and without zigging and zagging, a re-invigorated national security apparatus in its efforts to implement the strategy?

6. The answers to these questions could at best be a qualified—and not a resounding—yes and, at worst, more negative than positive. We have a nuclear doctrine, but no counter-insurgency and counter-terrorism doctrine despite the fact that India has been the victim of externally-supported insurgencies/terrorism since 1956, and no counter-proxy war doctrine despite the fact that thousands of security forces personnel and innocent civilians have died due to Pakistan's proxy war since 1981—initially in Punjab and then in J&K.

7. Any doctrine, in order to be credible and to be able to produce enduring results, has to address the internal as well as external, professional as well as the political, economic and social aspects of threats to our national security from the cancer of externally-supported insurgencies and terrorism. While the external aspects have been receiving increasing attention with significant successes as evidenced by the recent changes in the attitude of the international community in our favour in relation to Pakistan-sponsored terrorism, the equally important internal aspect of identifying and attending to the grievances of the people falling prey to external machinations has not received the attention it deserves. So long as this aspect is neglected, the wounds will continue to fester even if we reduce and ultimately eliminate the external causes of aggravation.

JULIO RIBEIRO

Internal Security: Challenges

The two major challenges to internal security that confront the Indian State today are (i) the tremendous amount of hate generated by communal fanaticism on both sides of the religious divide and (ii) terrorism which has its roots partly in the same divide. There is insurgency in the North-Eastern States and naxalite activity in Andhra, Bihar, and some tribal areas involving the Peoples War Group or similar organizations on the far left. But easily the greatest threat comes from religious bigotry as it has the potential to affect the minds of average law-abiding citizens and thereby destroy the social fabric of the nation.

The communally inspired killings in Gujarat shocked the conscience of all decent human beings. But what is more chilling is the dimension of hate that has been so patiently fed and nurtured by bigots and fanatics of both communities. Their efforts have succeeded in polarizing not merely urban communities but also rural ones in the villages, where such feelings were never at the fore.

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India has a large Muslim population of nearly 11-12 percent which translates into 110-120 million people. India is a secular state and has necessarily to remain so. Every individual is free to practice and propagate his own religion as long as it does not hurt the religious sentiments of others. Hinduism, which is the religion to which 85 percent of the population belong, has traditionally been a tolerant religion which has in the past millennium accepted and assimilated other religions like Judaism, Christianity, Islam and Zoroastrianism. It also has its own home -grown religions like Buddhism, Jainism and Sikhism. In recent years as political parties in a democratic set-up vie for votes and power, religious cards are being played with the sole purpose of acquiring or holding on to power. Again, I will not go into the history or the causes of communal conflicts in our country but shall refer to two developments, which have influenced the political climate in the past two decades. In 1985 the Allahabad High Court upheld the Muslim woman's rights to maintenance in case of divorce in the path-breaking Shahbanu case. It was a decision welcomed by all liberal and right-thinking citizens in the country including those who followed the Islamic faith. In other Islamic countries the rights of divorced Muslim women had been more liberally defined and respected but in India with its minority Muslim population trying to assert its individual identity, its religious and political leaders forced the Congress Government of the day to neutralize the beneficial effects of the judicial fiat through the misconceived use of the legislative process. This move, which smacked so openly of political opportunism and ignored feminine rights and common decency, opened a path to political opportunism. It led to an agitation that had an appeal to ordinary Hindus for building a Ram Temple in Ayodhya on the spot where a mosque then stood. It led to the destruction of the Babri Masjid, which in turn led to bloodshed in many parts of India. The communal riots that followed shook every nook and corner of the country. In Mumbai it culminated in terrorist bombings of the Stock Exchange, the Air India and other buildings and places. The relations between the communities have never been as bad as in the past decade. What happened at Godhra, Ahmedabad and Vadodra shamed the entire nation.

What is the role of the police in maintaining communal harmony? In recent years it has gone beyond the traditional role of putting down riots and rioters and keeping order on the streets to actually attempting to bring the communities together in peace time with the help of concerned citizens. In Mumbai, for instance, after the terrible riots of 1992 – 93 citizens belonging to different communities got together in cooperation with the police in an attempt to neutralize the effects of divisive and communal politics. It is not an easy task and the hurdles are not only numerous but also difficult to surmount. But a start has been made and it has been noticed, and in many cases it has proved, to be of use to the people of the city.

The policeman in uniform is supposed to shed all thoughts of caste, community, regional or linguistic identity. He is sworn to uphold the law of the land and the law of the land makes no difference between individuals on the basis of sex, status, caste, community, religion or language. All citizens are equal, nay all human beings are equal and even citizens of another country visiting India have the same rights with regard to life and property as citizens of India.

The unfortunate truth, however, is that the policeman is drawn from society and reflects the values and attitudes of the society from which he is drawn. If that society is violent there is a tendency for the policeman to be violent. If that society is corrupt or condones corruption there is a tendency for the policeman to be corrupt. If that society is affected by the communal virus or is caste conscious then the policeman tends not to forget his community or his caste even when he is performing his official duties. Attempts are made to correct many of these attitudes at the time of his training but in a society like ours it is not very easy to achieve success in changing mindsets.

The burden therefore falls on the police leadership, which is generally more liberal, secular, tolerant and broad-minded. If the leadership is convinced that these divisive tendencies have to be suppressed at the time of action on the streets it is almost certain

that the policeman will act according to the law of the land and carry out the orders of his superiors. The problem arises when the superiors themselves keep looking over their shoulders at their political mentors. I am quite sure in my mind that police leaders should have no occasion to decide on public order issues after consultations with the politicians in power. They can keep them informed of the situation on the ground or the action they propose to take or have taken but they certainly cannot accept instructions to treat with kid gloves those who are out to pillage or destroy or murder or maim in the name of God and religion

Communal tensions have increased in many parts of the country since the past two decades. Communal conflicts had arisen even in the days of the British and the first three decades after Independence. But there were clear instructions to put down such conflicts with a heavy hand. These instructions continue to grace the Standing Orders of every police department but the political will to implement these instructions in letter and spirit is definitely lacking.

It does the nation no good to perpetuate siege or ghetto mentalities. It retards the progress of the country and keeps entire police forces on tenterhooks particularly at the time of religious festivals when people should be rejoicing, and fighting should be the last thing on their minds. It is truly ironic that festivals are the most trying times for the police and test their morale, their stamina and their efficiency. More than that, they test the leadership and this constitutes a good reason why the selection of police leaders should be carefully undertaken.

The second major problem that poses a challenge to the managers of internal security is terrorism. This phenomenon was first noticed in its modern form in the State of Punjab in the early eighties. In the classical modern version of the nationalist form of terrorism (as differentiated from the ideological form which is confined to left-wing extremism) non-combatants of a particular community or religious denomination are routinely targeted in order

to spread terror and thereby force the State to concede demands which the perpetrators would not be able to extract through traditional or guerilla warfare.

The IRA in Northern Ireland and the LTTE in Sri Lanka are the biggest practitioners of this type of terrorism in the world today, along with the ETA in Spain and Hamas in Palestine. All these terrorist groups operate on their own whereas the Lashkar-e-Toiba, Harkat-ul-Mujahidin and the Jaish-e-Mohammad, operating in the Kashmir Valley since the last decade, are being actively encouraged, even raised, funded, trained, manned, and led by foreign elements. The hand of Pakistan's ISI is quite apparent and now even universally acknowledged.

The classical method of fighting this form of terrorism is to send in security forces to eliminate the terrorist but, at the same time, winning the hearts and minds of the general population whose ethnic or religious sentiments make them sympathetic to the terrorists and prompt them to provide tacit support and sometimes even overt help to the terorists in the shape of logistics, shelter or even storage of arms. The job of the security forces is rendered doubly difficult because of the vigilance of Human Rights activists who more often than not are very quick to condemn "State terrorism" while conjuring excuses for the unpardonable terrorist crimes of the self-styled freedom fighters.

For the past decade the border State of Jammu and Kashmir has been embroiled in a proxy war. The border States in the North-East have been afflicted by tribal insurgency almost since Independence. The States of Manipur and Tripura, in particular, are the most affected. Assam is also troubled. The tribal Bodos demand a separate homeland and the U.L.F.A. rebels want the migrants from Bangladesh expelled. All these insurgents have established camps in neighbouring countries, in Burma, Bhutan and Bangladesh, from where they carry out sporadic but effective strikes.

Maoist groups like the P.W.G. dominate the forests of Andhra Pradesh. In places they run parallel administrations levying taxes

on the forest contractors and collecting duties from the Government's own employees. Their influence has spread north cutting through a corridor that traverses the states of Orissa and Bihar and penetrates into neighbouring Nepal.

The ISI has exploited the social and economic discontent of the masses and made contact with the different insurgent groups in all these States. A string of Madrasas has suddenly sprung up on the borders of Nepal and in parts of Bengal and Bihar disseminating propaganda on communal lines.

The 'Madrasa' system of education that is common in Islamic countries needs some examination. Just because some 'Madrasas' have become centres for brain-washing and training terrorists it does not mean that the institution itself should be condemned or the traditionally run madrasas be pilloried. A fine distinction must be made through a properly- directed and properly- supervised intelligence machinery to ensure that madrasas are not misused for political or anti-national purposes. The traditionally- run madrasas in fact provide mainly religious instruction to the very poor sections of the Muslim community. Their infrastructure can be utilized to extend the scope of education to the more mundane aspects of living in order to fight illiteracy and poverty, and make the community better equipped to integrate with the national mainstream.

The latest report on Internal Security presented by the Home Ministry to the Parliamentary Committee on Home Affairs shows that out of the 535 districts in the country as many as 210 are affected by grave problems of public disorder such as insurgency, militancy, ethnic strife, terrorism or communal disturbance. As the maintenance of public order and control over the police is in the hands of the State Governments, there is always a tendency for the Central Government and State Governments to shift blame on each other. State Governments resent interference by the

Center. At the same time they castigate the Center for not coming to their aid in sufficient measure when situations go out of their control. As opposing political formations come to power in the Center and in the States, these differences are accentuated.

The tragedy is that situations go out of control either due to mismanagement of law and order issues or mismanagement of the police machinery by the State Governments themselves. Very often, contradictory approaches to political problems by the Central Government and State Governments result in a game of one-upmanship with consequent adverse results, a breakdown of public order on the streets, which inconveniences the public.

The mismanagement of issues can often be traced to political compulsions but the total mismanagement of the police machinery is purely a case of political leaders wanting to satisfy their own or their party interests to the detriment of the public good. The rapid politicization of the police forces in the country, through the one instrument of appointment and transfer of officials, has led to a situation where the law is enforced not according to the statute books but according to the wishes of the politicians in power. This is a recipe for disaster and unless it is corrected quickly and effectively we will be sacrificing internal security at the altar of political expediency.

The rule of law cannot be ensured merely by enacting strong codes. The test lies in enforcing the laws and it is a matter of serious concern that law enforcement in our country has been progressively weakened by persistent political interference and corruption. From being described as "a functioning anarchy", the country is now being portrayed as "a land of a million mutinies". The politicization of the public services has had the most deleterious effect on the functioning of the police, which is the instrument through which law and order is maintained. The eminent jurist, Lord Holmes, said, "There can be no case in which the lawmakers make certain conduct criminal without thereby showing a wish and a purpose to prevent that conduct". If a law is enacted and brought into force it must be enforced properly. The law should

not be seen to sit by limply while those who defy it go free and those who seek its protection lose hope. Unfortunately, this is precisely the situation which obtains in our country today.

Because of vicious communalism, as portrayed so vividly and so recently in Gujarat, and because terrorism has become so intimately a part of our existence, I did not give due importance to that other major challenge to internal security, that is, the play of underworld muscle and money power on the body politic. The dominant position that the criminal elements have been accorded in our cities by our venal politicians, aided and abetted by corrupt bureaucrats and police officials, has been succinctly described by the former Union Home Secretary, N. N. Vohra, in his celebrated report.

That report was written a good ten to twenty years ago! The situation has worsened since. The criminal underworld is even more powerful now as the thirst for money and muscle to fight elections is never quenched and politicians of every hue forget morality, ideology and the people in their quest for power. Since no politician and a rare bureaucrat / police officer is ever caught or punished, the race for wealth and power goes on at the cost of the people and to the detriment of good governance. If we wish to change this we must think of establishing a professional police force divorced from politics or political influence.

No police force can function without discipline. Ask any senior police officer in the country and he will tell you that political pressure in the matter of promotions, transfers and postings, even rewards and punishments, specially the latter, has adversely affected the discipline, efficiency, loyalty and morale of his force. Transfers are no longer related to well laid down tenure policies. They are determined on the basis of political expediency and even worse, on considerations of caste, community and the affinity of functionaries to given political personalities or groups. Officers are retained at their posts for only as long as they remain loyal or faithful to their political mentors who positioned them. The day-

to-day transfers of functionaries at all levels has resulted in chaotic police functioning, especially in the districts. The constant threat of being transferred and a lack of assured tenure have had a serious adverse effect on the initiative of personnel at all levels.

The functioning of the state police forces has been progressively neglected for years now. While the duties and responsibilities of the police have continuously increased, the conditions in which they work and live have been deteriorating sharply. Studies carried out by the BPR and D show that

1) 25% of police stations and 50% of police outposts do not have regular buildings.
2) 37% of police districts work out of makeshift police lines.
3) 70% of police districts do not have proper control rooms.
4) in 30% of police districts the Superintendents of Police do not have official accommodation.
5) 70% of the constabulary have no residential accommodation.
6) in metropolitan cities constables live in slums.

In insurgency and terrorist-affected areas, lack of secure accommodation near the police stations exposes the families of policemen to terrorist and militant strikes, inevitably affecting their performance.

I need not mention here the other deficiencies in infrastructural facilities which affect police working. Every citizen knows that the state of police mobility is woeful with 43% deficiency, which hampers the effective discharge of law enforcement and investigative functions. The communication networks are outdated and so is the equipment. Organized criminals are much better equipped in all these respects. Training institutions lack even

minimum facilities and above all they lack dedicated, committed and competent training staff.

India has achieved a phenomenal growth in socio-economic terms in the past fifty years since independence. Many millions have joined the ranks of the middle class, of the haves, and this in turn has been accompanied by a change in the value systems that inform civil society. Expectations have risen not only among this new middle class, which often resorts to quick means to acquire riches, but also among the have-nots who for the first time have been exposed to the possibility of living better. This revolution has come about through television. Cable television has penetrated the villages of India and shown the usually resigned villagers what they can expect.

The gradual breakdown of the joint family system and the caste system which underpinned the dominant Hindu society has led to the migration of vast numbers of the dispossessed from the villages to urban areas. The rapid urbanization of India has created social tensions and resulted in burgeoning crime with the emergence of underworld gangs, which thrive on the nexus between crime and politics. This nexus has drawn into its vortex the bureaucracy and the police, because without their help the arrangement would not have worked.

While economic growth has provided new opportunity to millions of people it has also opened the doors to violent means of grabbing these opportunities. At times the disparities in economic and social status lead to fierce competition for a better quality of life. It also leads, as I mentioned earlier, to movement of people both within and outside the country. When migrations follow demographic patterns they lead to communal or caste tensions. Since the Muslims and Scheduled Castes form the economically weaker sections of Indian society they are the first to migrate in larger numbers. Added to our problems is the fact that community and caste are exploited by electoral politics. The scenario is further complicated by the massive diffusion of illegal weapons in civil

society. Lastly, it should not be forgotten that India is located in the middle of two of the world's three largest drug producing and exporting areas, viz. the Golden Crescent and the Golden Triangle. Narcotics - trafficking has compounded all our security problems due to the insidious role of corruption and black money in the economic and political life of the country.

If the politicization of the police forces is one of the prime factors responsible for the deterioration of law and order management an equally important culprit is the breakdown of the judicial system. There was a time when the law was respected. There was a time when people were ashamed of breaking the law and there was a time when offenders feared being caught for committing crime. All shame and much of the fear has now disappeared. The entire value system has changed to such an extent and corruption has penetrated so deeply into the body politic that neither witnesses nor investigators, neither prosecutors nor magistrates are immune to temptation. Perhaps the biggest culprit is the defense lawyer who makes it a profession to suborn witnesses and arrange for the adjournment of hearings on the slightest pretext when the going is not favourable to his clients. Instead of thwarting such designs the magistrate takes the easy way out. Very often he has been approached by the accused, a phenomenon that is becoming more common as time goes by. We are today in a sad situation where very few criminals are caught and if caught hardly any are punished by the courts after trials which may take 5/6 years to complete! The end result is total contempt for the law by the wrongdoers and a cynical acceptance of the inevitable by a long-suffering public. If immediate measures are not taken to correct this situation chaos will rule and gangsters and criminals will become our rulers.

One of the most dangerous results of the breakdown of the judicial process is that the police under pressure from the public and the political leaders, have begun taking the law into their own hands and shooting gangsters on the streets instead of arresting them and arraigning them before courts of law. This license given to

the police to kill is a very dangerous trend, which will turn many of the more unscrupulous police officers into killers and criminals. There is a chance that they will accept contract killing themselves or play one set of gangsters against another. This is happening for instance in the city of Mumbai and I dread the consequences.

The only way out of this morass is for all concerned, i.e. the police, prosecutors, bar councils, judiciary, and jailers to sit together and thrash out a solution to this problem. If they do not do this in a hurry or if the judges stand on a high pedestal and refuse to rub shoulders with the others, the societal consequences are bound to be grave. We are reaching a point of no return and before that happens let these gentlemen sit together for their own good and for the good of society as a whole.

M K PAUL

"Disasters - How Others Manage"

Based on Visits to USA and Germany

1. Background

Apart from normal activities of the Institute, NIAS has been dealing with subjects of topical importance to society. Thus, NIAS has been for quite some time involved in conducting Seminars, Workshops, Round Tables, Courses etc. covering issues related to problems of development of infrastructure and management of disasters. These were:-

(1) On 13 June 1997, the first Seminar in this series was held on the theme *"Infrastructure – key to growth: is Karnataka geared up"?*

(2) On 25 September 1998, a Round Table meeting on *"Decongesting Bangalore"*, jointly sponsored with the State Planning Board. Major recommendation was construction of *"A high speed twin-track electric rail link between Bangalore and Mysore"*. The recommendations of the meeting were accepted in principle by the State Government as well as the Railway Ministry.

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(3) On 27-28 November 1998, the second Seminar was held. It discussed the "*Status of infrastructure in Karnataka - a year later*".

(4) On 1 July 2000, the third Seminar in the series was held. It covered *"Water resources management and transportation, including mass transport system and IT in construction management"*.

During the Seminar on Mass Transport our recommendation was that Elevated Light Rail Transport System (ELRTS) in Bangalore would not be technically and financially viable. After many years of deliberations, the State Government has now come to the conclusion that it will not go ahead with the ELRTS proposal.

(5) On 6-10 August 2001, the second NIAS Course for Senior Level IAS Officers on *"Disaster Management"*.

(6) On 25 August 2001, a National Seminar on *"Organisation and Infrastructure for Management of Disasters"*.

An important aspect of this seminar in particular was that an exclusive core-group meeting was held after the seminar was over. The participants of this core-group meeting included a cross-section of the chairpersons of the sessions, important speakers and other representatives from the armed forces, media, government, policy- makers, scientists, and humanitarian agencies. It was suggested that it might be useful to consolidate the recommendations into implementable strategies.

(7) On 24-28 June 2002, the third NIAS Course for Senior Level IAS Officers on *"Disaster Management"*.

For many years, disasters of all kinds have afflicted the nation. In most cases, there was-large scale public dissatisfaction with the attempts at managing these disasters.

The post- 11 September 2001 scenario drew a lot of attention to America and its allies dealing with the initiators of such a calamity. The media did not highlight the management aspect of this catastrophic disaster. It was felt that a disaster of such magnitude was well managed. The USA is also a highly disaster- prone country. Hence a brief visit to the USA was planned.

A short visit to Germany was also planned as Germany is renowned for its effective Disaster Management system.

This is a presentation based on the study of disaster management in both these countries on the spot.

2. Aim

The aim was to study how these countries anchor their disaster management mechanism at the grassroots as well as at the higher decision-making levels.

3. Programme of Visit

The programme of the visit is attached in **Appendix-'A'.**

4. Organizational Structure in the USA

a) FEMA and Stafford Act

The Federal Emergency Management Agency (**FEMA**) is an independent agency which reports to the President. FEMA assists State and local governments in preparing for and responding to natural and man-made emergencies including accidents at nuclear power facilities and accidents involving transportation of radioactive materials.

The Robert Stafford Disaster Relief and Emergency Assistance Act of 1988 (Stafford Act) authorizes the President and in turn FEMA to provide Federal support to State and local governments in disaster situations. The beginning was the congressional act of 1830 which evolved as a result of the extensive fire which destroyed New Amsterdam.

b) Types of Presidential Declarations

The Stafford Act authorizes the President to provide Federal Assistance to supplement State and local governments' disaster response, recovery, preparedness, and mitigation efforts. The Director of FEMA has been delegated the responsibility for administering the Federal government's disaster assistance programs. The Stafford Act authorizes five types of declarations or actions:

Major Disaster : The Presidential declaration authorizes FEMA to provide Federal disaster assistance programs. Each declaration specifies the type of incident, the time period, the types of disaster assistance available, and the States affected by the declaration and identifies the **Federal Coordinating Officer (FCO).**

Emergency: The declaration process for emergencies is the same as for major disaster. However, an emergency declaration authorizes only emergency response activities, debris removal, and disaster housing programs. Disaster Relief Fund expenditures for an emergency are limited to $5 million per declaration, unless Congress is notified otherwise.

Fire Suppression: The FEMA Director is authorized to provide fire suppression assistance to supplement the resources of communities when fires threaten such destruction as would warrant a major disaster declaration.

Defense Emergency: Upon request from the Governor of an affected State, the President may authorize the Department of Defense (DoD) to carry out emergency work for a period of time not exceeding ten days. DoD emergency work is limited to work essential for the preservation of life and property.

Deployment in Anticipation: When a situation threatens health and safety and a disaster is imminent but not yet

declared, the **Director** of FEMA may place Agency employees on alert. FEMA monitors the status of the situation, communicates with State emergency officials on potential assistance requirements and deploys FEMA teams and resources in advance to maximize speed and effectiveness of the anticipated Federal response.

In actual practice even on a telephonic request from the Governor of a State, the President may declare a "Disaster Situation" and all procedural actions follow later.

c) **FEMA Assistance Programs**

- **Infrastructure:** Repair and rebuilding of damaged infrastructure, immediate protective services and debris removal.
- **Human Services:**
  - Individual and Family Grants – provide people with finance to rebuild homes.
  - Disaster Housing – provides temporary shelter or quickly needed minor repairs.
  - Disaster Unemployment – provides benefits to people who lost their jobs because of the disaster.
  - Crisis Counseling – helps individuals (especially children) cope with a disaster's effects and begin planning their family's recovery.
- **Mitigation:** Grants to fund long-term projects which will reduce the impact on the cost of future disasters.
- **Mission on Assignments:** FEMA is authorized to pay other Federal agencies, when it asks another Federal agency to act in a disaster.

d) **Structure on the Ground - FEMA Regional Offices**
FEMA has 10 regional offices and two area offices located across the country - **Appendix-'B'**. It is an agency on

the ground easy to access. FEMA works in conjunction with the State Emergency Management Organisation (**SEMO**) and local bodies. 12 other government agencies also work under FEMA, whenever required.

Each regional office serves several States and the regional staff work directly with the states to help plan for disasters, develop mitigation programmes and meet needs when a major disaster occurs.

FEMA Region-II serves the needs of the State of New York, New Jersey, the Commonwealth of Puerto Rico and Territory of US Virgin Islands. Region-II employs 67 full-time employees and can draw on a cadre of 700 temporary disaster employees (reservists) during a Presidential Disaster Declaration.

e) Task Forces

There are 27 fully equipped Task Forces located strategically in various disaster-prone areas of the country **Appendix-'C'**. In addition, there are umpteen well equipped, sophisticated fire services throughout the country. Task Forces work in conjunction with Fire Services in case of a disaster situation. Details of function and organization of a typical Urban Search and Rescue Task Force attached **Appendix-'D'** and **Appendix-'D1'** shows an organizational chart of the Search and Rescue Task Force.

f) Federal Response Plan

When State and local governments are overwhelmed by a CATASTROPHIC DISASTER, the Federal government is called in at once to mobilize resources from any number of Federal agencies, and sometimes to perform the response functions normally carried out by the State and local governments. This is when the government implements the Federal Response Plan (FRP), though typically, the Federal

role is financial – low interest loans and grants to individuals, businessmen and communities.

As per the Response Plan, the Federal government provides State and local governments with personnel, technical expertise, equipment and other resources, and assumes an active role in managing the response.

The States and the Districts also have Emergency Preparedness and Response plans.

g) Managing Essential Services

Resources are provided by one or more of 27 Federal departments and agencies and the American Red Cross, and other NGOs including the Salvation Army. Federal resources are grouped into **12 Emergency Support Functions (ESF)**, including transportation, fire fighting, mass care, health and medical services, public works and urban search and rescue. Each ESF is headed by a Primary Agency. Other agencies provide support as necessary. Each agency responds within its own authority - **Annexure-I**.

Federal assistance is coordinated by the Federal Coordinating Officer (FCO), appointed by the DIRECTOR - FEMA, and the **Emergency Response Team (ERT).** They work from a Disaster Field Office (DFO) near the disaster scene. For example, the DFO near WTC site.

h) Example of Disaster Management at World Trade Centre

Within 24 hours of 11 September 2001, about two kilometers away from the WTC, a site office accommodation was hired by Regional FEMA Office for FEMA, SEMO and local bodies to work side-by-side and take on-the-spot decisions.

At ground floor level and on the main road under tents, victims' and their relatives' data were being collected on PCs and passed on upstairs to the Disaster Field Office. It was a great experience to observe how prompt decisions to provide help to victims by FEMA in consultation with the local bodies were being taken.

Medical help both for psychological and other cases was being provided jointly by FEMA and the American Red Cross and reservations were made in various hospitals in New York and neighbouring States for victims and their relatives on the highest priority.

At the disaster site, Task Forces and Contractors' machinery were working round the clock and also looking for vital clues with the FBI.

(i) Personnel –

- **Volunteerism**

All disaster management schemes in the USA and Germany are volunteer driven. Whether it is FEMA, SEMO or a Task Force, a small nucleus of staff is composed of permanent employees. But the rest are volunteers.

Volunteers are proud to be called in for service in disaster situations. The volunteers - both men and women - are mostly drawn from among college students, employees of companies, former defence services personnel and police officers, academicians, etc. The employers are also equally supportive of their commitments to the volunteer employees in case of emergency.

Strength : In the **USA,** FEMA itself has 2500 full-time employees spread over all the regions. It also has 4500 reservists. This strength does not include volunteers for various Task Forces and the fire services based in various States.

Training

The volunteers are very well trained, physically fit, patriotic and certified by training institutes, Task Forces and Fire Services.

FEMA operates National Emergency Training Centers. Importance is given to training exercises under simulated conditions. Task Forces and Fire Services have their own training facilities.

In fact, disaster management is a subject in colleges and universities and particularly in management studies. Universities of Missouri and New York amongst others have courses on disaster management in their curriculum.

How to manage disasters in business is also covered. Business houses are encouraged to have a recovery plan in case of natural or man-made disasters.

- **Awareness**

Due importance is given by the Government and NGOs to knowledge about emergency and disaster. Awareness programmes are conducted in schools and colleges, offices and commercial centers by FEMA and fire services. For schools and colleges, personal and community safety are covered at the practical level. This is more so due to the recent entrance of terrorism in this arena such as use of anthrax and other Bio-chem /Hazard materials.

- **Guidelines and Manuals**

In order to enhance awareness amongst all citizens, victims and stakeholders in management of disasters, FEMA has brought out a large number of guidelines and manuals. Some of them are (a) FEMA Emergency Information Field Guide– October 1998 - an extensive guide for all concerned, (b) Disaster Assistance: Guide

to Recovery Programme updated till December 2000, (c) Manual on Task Forces, (d) Public Assistance – Policy Digest, (e) Field Operations Guide, (f) Operations Manual – Community Relations and (g) Federal Response Plan, etc.

- **Transparency and Accountability**

  During an emergency or disaster, FEMA regularly publishes details of activity connected with disaster management highlighting the amount of finance spent on various sub-heads of disasters– number of people affected, latest progress and estimated time for completion of the tasks. The periodicity of such announcements as far as WTC is concerned is once a week. All kinds of media help is utilized for disseminating such information. A typical copy of a publication is attached as Annexure-II.

- **Budgetary Provision**

  FEMA prepares an annual budget request that is submitted first to the Office of Management and Budget for review, and then to Congress as part of the President's Budget. In an unexpected catastrophic situation arising at any time, special budgetary provision can be asked for.

5. Organizational Structure in Germany

The disaster relief organization of the Federal Republic of Germany is THW (Technisches Hilfswerk). Founded in 1950, it is a Federal agency within the purview of the Federal Ministry of Interior in Berlin. The Director of the THW and his headquarters are based in Bonn.

a) Functions

The functions of THW are defined in a Federal law. These functions consist in providing technical relief in the sectors of civil defence, disaster relief and international

humanitarian assistance. The main fields of activity are rescue, salvage and rehabilitation of infrastructure including water, electricity, sewage, etc.

b) Organizational Structure

Under the jurisdiction of THW headquarters there are 8 offices of state commissioners, 66 regional commissioners and 665 local sections with voluntary local commissioners spread across the country.

There are more than 44,000 active voluntary members, 17,000 reserve volunteers and 10,000 junior volunteers. The permanent staff is only 750.

c) Training

The main asset of THW is the professional knowledge of its volunteers. These volunteers represent a wide range of technical and other professions with various levels of expertise and experience. THW members receive special training in several stages in the local sections and in the two THW training centers. The training concentrates on additional skills needed for national and international relief missions. If a volunteer serves in THW for six years, he need not be conscripted. So long as there is conscription in Germany, THW will flourish so far as volunteers are concerned.

d) Units and Equipment

Throughout the Federal Republic, THW maintains 810 technical platoons, each with 40 volunteers. Each platoon consists of one command squad with 4 volunteers and three special sections with 12 volunteers. The units are highly equipment-intensive, with high- frequency tools and modern equipment. These units were found to be very innovative and at on the wheel round-the-clock in a state of readiness.

e) Types of special sections in THW

- Command, control and communication
- Rescue and salvage
- General infrastructure
- Debris clearance
- Boat and pontoon
- Electric supply
- Search and detection
- Pumping and sewage
- Logistics
- Water supply and treatment
- Temporary bridge construction
- Oil pollution
- Sections of the Rapid Deployment Unit for Search and Rescue

Each unit is provided with the specific equipment it needs, i.e. emergency tenders, tool and gear carriers with special equipment and material, personnel transporters, trucks, emergency power generators, water treatment plants, trailers (e.g. for equipment), cranes, multipurpose bulldozers and boats. In all over 6,000 vehicles are at the disposal of THW.

f) Missions

In Germany, THW is requested to help in many cases of emergency, particularly when its equipment and the special skills of its members are needed for assistance in local or regional emergencies. The Federal Government has frequently ordered THW to provide international assistance in crisis situations such as earthquakes, flooding, drought and refugee emergencies. In general, these operations are integrated into plans of action of the European Union

or the United Nations. As of today, THW has carried out hundreds of missions abroad, many of them in Africa. The Gujarat earthquake was also attended to by the German Emergency Relief Team.

g) Mobility

The organizations are very prompt and swift in their movement. For response to long distance disasters, required contingents are flown by chartered aircraft. THW teams are mobilized to move for regional tasks within 2-3 hours but for emergencies abroad, these teams can take off in 6 hours. For earthquake, ideal time to reach site is within 48 hours. Department of Defence is hardly involved. In the USA, it is the Air force which airlifts the task forces (if required).

h) Finance

More stringent than in the USA. Budgetary provision is by the Ministry of Interior.

6. Situation in India

There is no doubt that as of now disaster management on the ground is far from satisfactory, except may be for Andhra Pradesh. The impact of hazards in India gets multiplied many times mainly because of poor infrastructure, high density of population and the existing poverty level in some of the disaster-prone areas.

High Power Committee

It is not that India has not done anything in this regard. It is only after over fifty years of independence that the High Power Committee (HPC) for preparation of disaster management plans at national, state and district levels was constituted at the behest

of the Prime Minister in August 1999. The committee took over two years to submit its report in September 2001.

The report is quite comprehensive and has emerged as a result of interaction with State governments, NGOs, national and international agencies and media organizations who had with disasters in the past. Their recommendations became the basis of the HPC's recommendations for planning, prevention and preparedness as against only response, relief and half-hearted rehabilitation at various levels in the past.

Though the HPC was instituted to streamline the Disaster Management Process in India, action on the recommendations is still to be finally and fully decided upon by the Government. There is a proposal to have a National Calamity Management Act which is still to be passed by Parliament. This will take time.

The HPC has recommended a number of committees/councils such as Cabinet Committee on Disaster Management (CCDM), National Council of Disaster Management, Department of Disaster Management and Mitigation, National Centre for Calamity Management (NCDM), National Institute for Disaster Management (NIDM) etc. Almost all of these organizations are Delhi-centric, the theme being that the Centre will support but the responsibility of disaster management is that of the State.

The HPC has suggested a change in the nomenclature of certain organizations and functionaries such as Relief Commissioner to be changed to Commissioner or Secretary in charge of Disaster Management at State level, Resident Commissioner of each State positioned in Delhi to be designated as Ex-officio Special Commissioner of Disaster Management. The change in nomenclature without change in structure and authority will not be effective on the ground.

The following points need to be considered:-

Legal Framework: Disaster management does not find a place in any of the three lists laid out in the constitution (Central, State and Concurrent lists). As recommended by the HPC, there is need for including disaster management in the lists by suitable legislation. Thereafter, the Disaster Management Act needs to be passed by Parliament.

Organisation: For effectiveness on the ground, the Centre should reach out to States and local bodies as in the case of FEMA. At least in disaster-prone States and in remote areas, the Centre should continuously monitor, plan for preparedness, prevention, short- and long-term rehabilitation etc. along with the State. This will facilitate close interaction and swift and speedy action on the ground, such as operating from a Disaster Field Office – where necessary.

Task Forces: The effectiveness of well equipped and trained task forces has been proved beyond doubt in both the countries. Apart from the ministries, it is for consideration whether we should raise certain task forces at least in disaster-prone states, and equip them with modern tools and accessories and keep them in an alert state of readiness.

Personnel: At the moment there is no scheme anywhere in our country for raising volunteers and training them for action during disasters. It is for consideration whether India should adopt volunteerism in disaster management organization since this is very effective. Volunteers should be from community to State levels.

Training: Training at national and State institutions should be not only for officials but also for NGOs and volunteers. On the job training of volunteers including simulated exercises should be a regular feature.

Ministry: In India, National Disaster Management activities are under the Ministry of Agriculture. At State level, the ministries responsible for disaster management vary from State to State. In some States it is under the Department of Revenue. Considering the security aspect of man-made disasters, it is for consideration as to which is the best Ministry to coordinate.

Awareness: Awareness programmes start from school onwards ending with disaster management as a subject in various universities/colleges etc. In India, we should have similar schemes. There should be as many manuals, guidelines and handouts on disaster management as possible for all concerned including the likely victims.

Command, Control and Traffic Management: This is a very weak area in our system. Strong monitoring cells along with properly networked sub-cells must be positioned in appropriate locations. Maps with guidelines for directing flow of resources as planned and controlled by police forces need to be instituted and simulated exercises undertaken during training. A strong traffic management system will ensure resources reaching the correct location and the correct people.

Equipment: Earthquakes, serious fire hazards, cyclones, floods, etc. need specialized equipment. In India, we hardly have any standby equipment other than what is available with the defence services which is meagre compared to the requirement. This needs to be organized.

Transparency and Accountability: During an emergency or disaster, concerned agencies in the USA regularly publish details of activity connected with disaster management, highlighting the amount of finance spent on various sub-heads. We need to institute such a system.

Budgeting: Budgeting forms part of a regular budget approved by the Federal government in both the countries. In India, no

such arrangement has yet been made, though HPC recommends that 10% of the Central and State budget should be earmarked for disaster management. Earmarking alone will not do. Disaster management budget should be a part of the regular budget. There is a Calamity Relief Fund which is supposed to be formed with 25% central support and 75% State support and there is also the **Prime Minister's Fund**.

Special Features: In the USA, the government is approaching scientific institutes to find out ways and means of tackling hazard material and other man-made disasters. Building Codes have been revised and FEMA has issued construction drawings for non-destructive shelters in the basement of houses that are normally affected by disasters. These shelters have disaster kits for the users. We may think on these lines. Special attention needs to be given to man-made disasters.

Management of Media: Positive media interaction will motivate management of disasters.

Department of Defence (DOD): In the USA, the DOD is the last to be tapped and needs the President's permission. Moreover, it cannot be used for more than ten days. We should gradually reduce Services' involvement. This is possible if task forces are raised. In Germany too, DOD is rarely requisitioned.

Insurance: Possibility of insurance cover in disaster-prone areas (both rural and urban) against loss of property and domestic animals such as cattle needs to be explored.

Weakness: The weakness in the USA is twofold:

(a) Donations in kind in huge numbers and mostly unwanted ones create problems of traffic and storage. For WTC, eleven huge hangars were to be hired for storage of unwanted donations in kind by the Salvation Army. In India also a mechanism by which only required resources in kind are received with details of quantity,

delivery points and cut off time etc. needs to be drawn up.

(b) There are cases of relief which was duplicated by FEMA as well as insurance. This could happen in India also and needs to be looked into.

7. Conclusion

Having brought out the differences in almost all aspects of disaster management on the ground in the USA, Germany and India, it is for consideration as to what aspects of structure, equipment, training etc. of the other two countries can be either fully incorporated or partially adapted to our conditions.

It is not necessary that we follow all aspects of their mechanism as cost effectiveness and conditions peculiar to our country have to be taken into account.

The disaster management mechanism in both the countries is very much action-oriented and rooted to ground level. Availability of modern equipment, transportation, training and volunteerism basically makes the organizations on the ground very effective.

Conditions in the West and in our country vary. But we can decidedly benefit by introducing certain ideas from these two countries in our concept of physically providing disaster management support on the ground. These are:

(a) **Central Support:** More prompt Central support to the State in national disasters, natural or man-made. In disaster-prone States, Central agency needs to work with the State disaster organizations either throughout the year or well before disaster is expected to strike. It is important to make an effort to sensitize different players and to re-emphasize the role of stakeholders, particularly the affected people and the community, in relief and rehabilitation.

(b) **Act:** The National Calamity Management Act should be passed at the earliest so that all concerned draw authority from this Act.

(c) **Task Force:** Though not on a very large scale, but decidedly in disaster-prone states, Task Forces with modern equipment, transportation and volunteers need to be raised so that in case of disaster, there is no loss of time in directing their effort. There should be co-ordination between the Task Forces and NGOs.

(d) **DOD:** Dependence on defence forces should be gradually reduced. Strengthening Task Forces with improved training and simulated exercises is a must for effective results on the ground.

(e) **Budgeting:** Budgeting for disaster management at the Centre and in the States should be made a part of the normal budgeting process. There is hardly any fund in the budget earmarked for disaster management in various States.

(f) **Public Awareness:** Public awareness with regard to organizations responsible for springing into action when a disaster strikes their area is a must. This can be done by conducting various awareness programmes in schools, colleges, universities, villages and urban areas through government agencies including Task Forces and NGOs. As many guidelines on disaster management as possible in local languages should be prepared and issued to disaster-prone areas and these should be available in all local offices.

(g) **Interaction:** During simulated exercises, networking and coordination, swiftness in operation between government agencies and NGOs, victims and other stakeholders should be extensively practised.

(h) **A Strong Monitoring and Control Cell** is a must for effective management.

Appendix-'A'

Programme of Visit

U.S.A. (18–26 January 2002)

- **St Louis, Columbia :**
  Visited a specialized Fire Service organization and a Federal Urban Search and Rescue Task Force. Was briefed on organization, training, volunteerism and salient aspects of managing wild land fire, various kinds of accidents leading to fire along with demonstrations on actual realistic training, etc. Was also briefed on the role, organizational structure and training of a Federal Task Force in disaster situation.

- **New York :**
  Extensive briefing on American Red Cross. Visit to World Trade Centre (WTC) site, briefing on Federal Emergency Management Agency's (FEMA) role in WTC, meeting the Regional Director of FEMA including visit to Disaster Field Office in New York and Monitoring Center for Victims. Attended an international Urban Hazards Forum covering terrorism, catastrophic events and mitigation organized by John Jay College of Criminal Justice at the City University of New York.

- **Washington DC (2 days):**
  Briefing at FEMA headquarters by the Deputy Director. Visit to US aid programme for disasters abroad - briefed by Mission Control Leader. Visited headquarters of Salvation Army and India Desk Official of the State Department.

- **Germany (27-30 January 2002)**

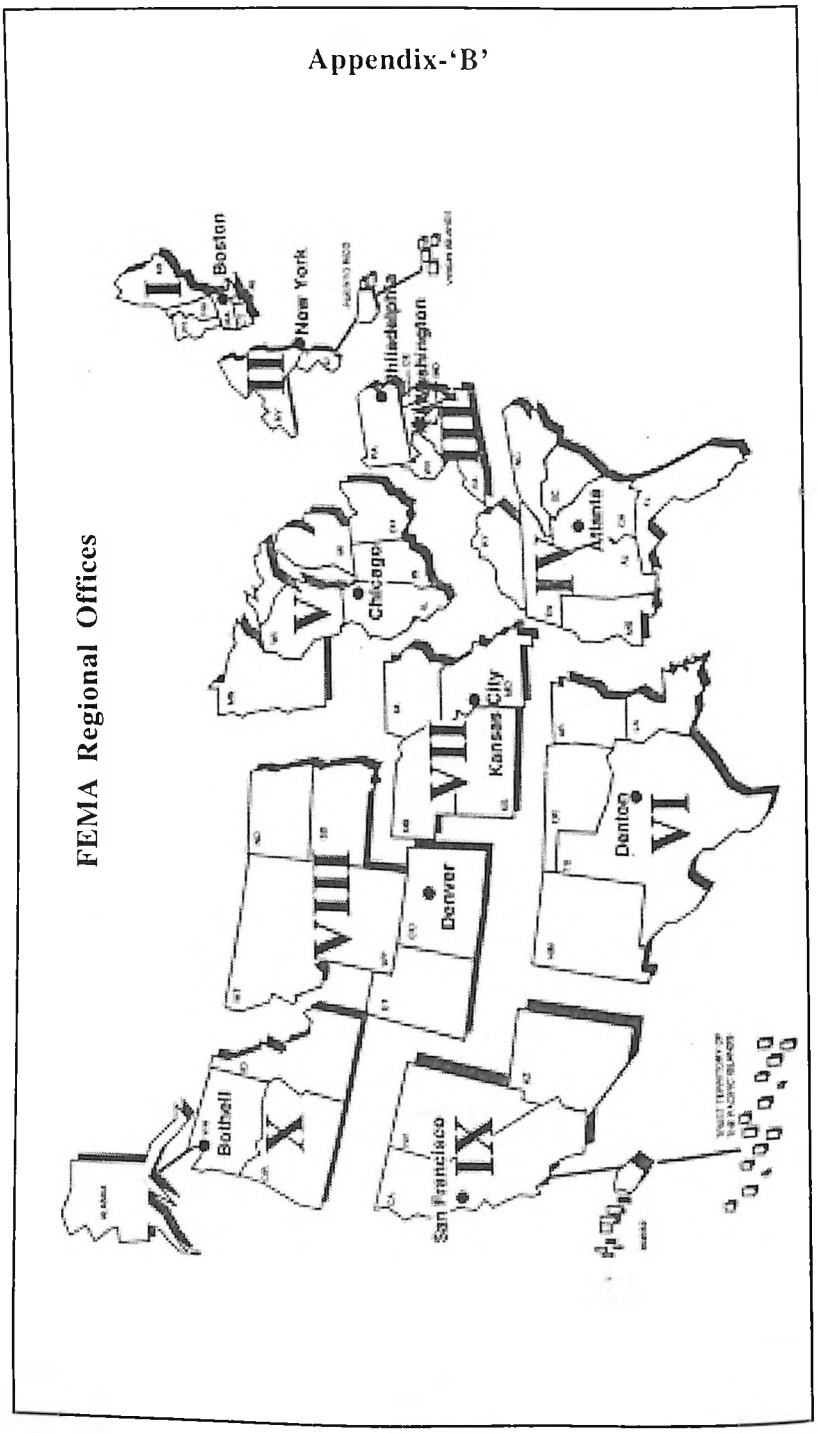
- **Berlin :**
  Visited the Interior Ministry Headquarters and was briefed by the Third Secretary on monitoring and management of disasters. Visited Charlotten Fire Station which is claimed to be the best in Europe.

- **Potsdam:**
  Visited the Centre for Research on Earth Sciences. The scientists of the Centre can predict eruption of dormant volcanoes and provide information three days in advance.

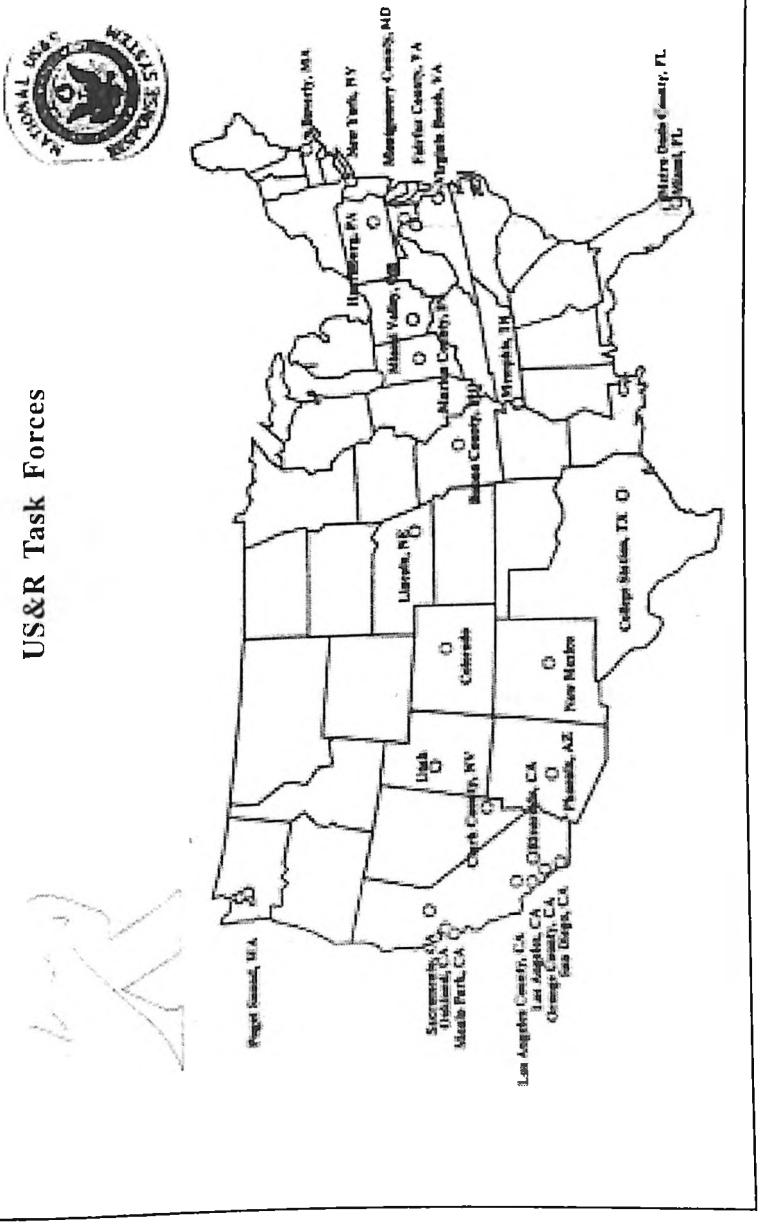
- **Bonn :**
  Federal Agency for Technical Relief (THW) and the THW headquarters. Briefing on Germany's disaster management scheme both local and abroad.

- **Darmstadt:**
  Attended a Technical Task Force capability demonstration.

Appendix-'B'


FEMA Regional Offices
Boston
New York
Philadelphia
Washington
Atlanta
Chicago
Kansas City
Denver
Denton
Bothell
San Francisco
I
II
III
IV
V
VI
VII
VIII
IX
X

Appendix-'C'


US&R Task Forces
Beverly, MA
New York, NY
Montgomery County, MD
Fairfax County, VA
Virginia Beach, VA
Miami-Dade County, FL
Miami, FL
Pittsburgh, PA
Miami Valley, OH
Memphis, TN
Marion County, IN
Indiana County, IN
Lincoln, NE
College Station, TX
Colorado
New Mexico
Utah
Clark County, NV
Phoenix, AZ
Riverside, CA
Los Angeles County, CA
Los Angeles, CA
Orange County, CA
San Diego, CA
Sacramento, CA
Oakland, CA
Menlo Park, CA
Puget Sound, WA

Appendix-'D'

A Typical Urban Search and Rescue Task Force

An Urban Search and Rescue (US&R) Task Force is organized as given in Appendix-'D1' It is a 62-member team that is qualified and equipped to search for and rescue victims trapped in collapsed reinforced concrete and steel structures. The Task Forces are most suited to handle earthquakes and building collapses due to man-made disasters. A US&R Task Force, at its most effective level, is a highly sophisticated personnel-, equipment- and training- intensive program. It also requires a significant investment in time, management, training and equipment. The Task Force, depending on the status of the disaster, must respond so as to be at the site within 6-8 hours. Often the Task Force works in unison with Fire Services. The Fire Services take off for emergencies within seconds.

An extensive equipment cache is maintained to support the Task Force. Task Force members receive hundreds of hours of highly specialized training. It trains and assists in the development of regional teams also.

Process of Rescue

1. At the most basic level, in an earthquake-prone area, citizen volunteer groups, otherwise known as Community Emergency Response Teams (CERT), are trained in basic firefighting, emergency medical care and surface search and rescue skills. These local first responders are the community's first line of defence immediately after a catastrophic event.

2. Local search and rescue teams receive additional training to form the second tier of the response. Local fire departments, sheriff's departments, rescue squads and ambulance services know how to perform basic structural collapse search and rescue and assist in the development and instruction of Community Emergency Response Teams.

3. The next tier is made up of the regional search and rescue teams. These teams are located strategically throughout the State in locations corresponding to the State Highway Patrol regional offices. Regional teams are trained in intermediate structural collapse search and rescue and will have access to the specialized rescue equipment cache that allows them to rescue victims trapped in collapsed reinforced masonry and wood frame construction. Members of the regional teams train and assist local teams with their development.

4. The final tier is the State Urban Search and Rescue Task Force. The Task Force is developed utilizing the operational standards, training criteria and equipment requirements of the Federal Emergency Management Agency (FEMA).

Training

To ensure the availability of a 62-member Task Force, 186 personnel must be trained and equipped pursuant to Federal guidelines. All personnel assigned to the Task Force volunteer their time and effort.

What does it take to rescue people trapped in collapsed buildings?

The process of locating, accessing, removing and providing medical care to persons trapped in a collapsed building is an equipment- and personnel- intensive operation. Four distinct and specific areas make up the US&R Task Force – Search, Rescue, Medical and Technical. Essentially, a rescue progresses somewhat like this:

The SEARCH GROUP ventures around and into the collapsed structure attempting to locate trapped victims and identify dangerous areas. The team uses electronic listening devices, extremely small search cameras with fiber-optic capability and specially trained dogs to locate victims.

Once victims are located, the RESCUE GROUP goes about the daunting task of breaking and cutting through literally thousands

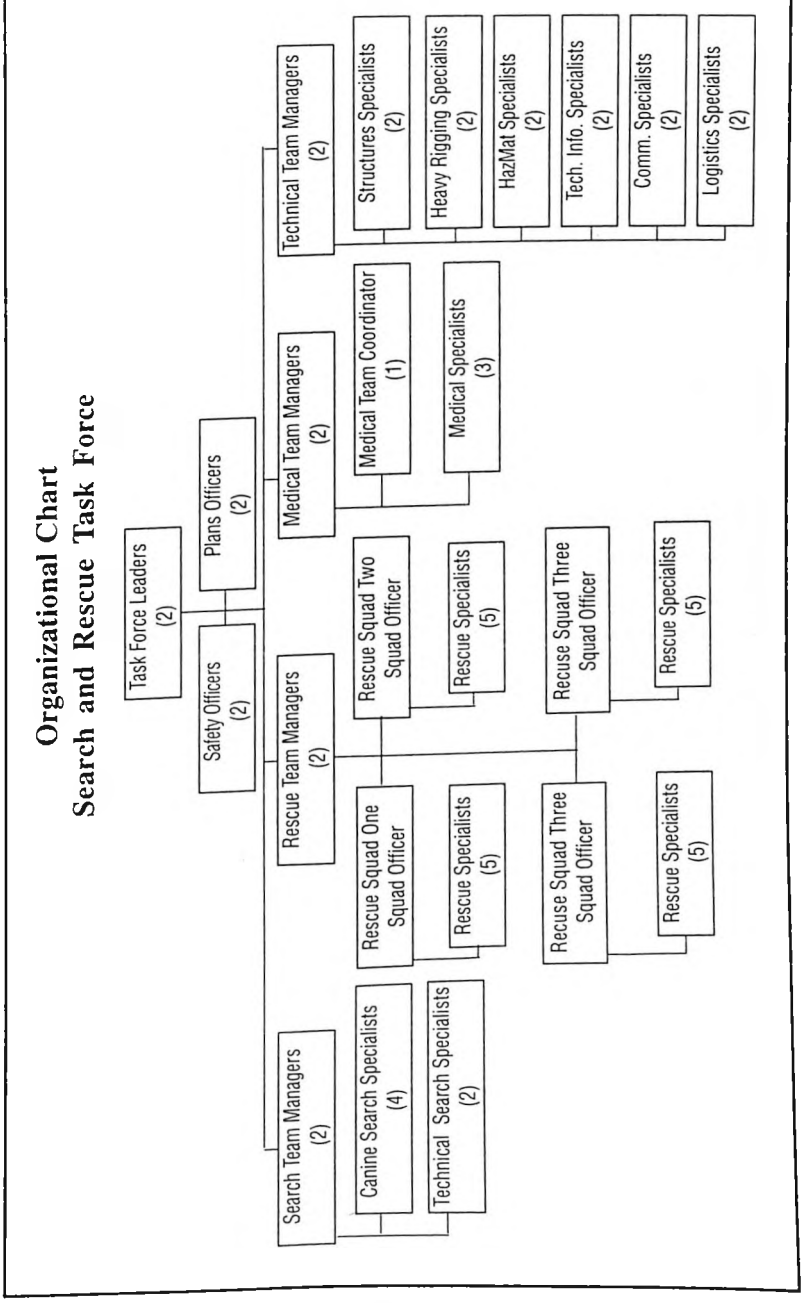
of pounds of concrete, metal and wood to reach the victims. The entry and work areas in and around the building must be supported with wood shoring to prevent further collapse. Equipment used includes bio-shielded concrete cutting chain saws valued at $26,000 and other highly expensive breaching and breaking tools. For shoring up, sophisticated large rubberized pillows are used initially.

Once the trapped people are reached, they must be freed by backing them out through the hole the rescue group made to reach them. They most likely will need medical attention, depending on the extent of damage and the duration over which the victims were trapped.

The **MEDICAL GROUP** composed of trauma physicians, emergency room nurses and paramedics provides medical care for the victims and the Task Force members. They enter the dangerous interior of the collapsed structure to render aid to the victims. A completely stocked mobile emergency room is part of the Task Force equipment cache. Many a time, Task Force members are severely injured in the process of rescue.

The **TECHNICAL GROUP** provides support and assistance of a technical nature to the other groups. This groups consists of structural engineers, communications specialists, hazardous materials specialists, information specialists, heavy equipment operators and logisticians who manage the entire equipment cache.

Appendix-'A'


Organizational Chart
Search and Rescue Task Force
Task Force Leaders (2)
Safety Officers (2)
Plans Officers (2)
Search Team Managers (2)
Canine Search Specialists (4)
Technical Search Specialists (2)
Rescue Team Managers (2)
Rescue Squad One Squad Officer
Rescue Specialists (5)
Rescue Squad Two Squad Officer
Rescue Specialists (5)
Recuse Squad Three Squad Officer
Rescue Specialists (5)
Recuse Squad Three Squad Officer
Rescue Specialists (5)
Medical Team Managers (2)
Medical Team Coordinator (1)
Medical Specialists (3)
Technical Team Managers (2)
Structures Specialists (2)
Heavy Rigging Specialists (2)
HazMat Specialists (2)
Tech. Info. Specialists (2)
Comm. Specialists (2)
Logistics Specialists (2)

ANNEXURE - I

12 Emergency Support Function (ESF)

ESF 1: Transportation
Responsibility: Provide civilian and military transportation support.
Primary Agency: Department of Transportation

ESF 2: Communications
Responsibility: Provide telecommunications support.
Primary Agency: National Communications System

ESF 3: Public Works and Engineering
Responsibility: Restore essential public services and facilities
Primary Agency: U.S. Army Corps of Engineers, Department of Defense

ESF 4: Firefighting
Responsibility: Detect and suppress wild land, rural and urban fires.
Primary Agency: U.S. Forest Service, Department of Agriculture

ESF 5: Information and Planning
Responsibility: Collect, analyze and disseminate critical information to facilitate the overall Federal response and recovery operations.
Primary Agency: Federal Emergency Management Agency

ESF 6: Mass Care
Responsibility: Manage and coordinate food, shelter and first aid for victims; provide bulk distribution of relief supplies; operate a system to assist family reunion.
Primary Agency: American Red Cross

ESF 7: Resource Support
Responsibility: Provide equipment, materials, supplies and personnel to Federal entities during response operations.
Primary Agency: General Services Administration

ESF 8: Health and Medical Services
Responsibility: Provide assistance for public health and medical care needs.
Primary Agency: U.S. Public Health Service, Department of Health and Human Services.

ESF 9: Urban Search and Rescue
Responsibility: Locate, extricate and provide initial medical treatment to victims trapped in collapsed structures.
Primary Agency: Federal Emergency Management Agency (Through US&R Task Forces)

ESF 10: Hazardous Materials
Responsibility: Support Federal response to actual or potential releases of oil and hazardous materials.
Primary Agency: Environmental Protection Agency

ESF 11: Food
Responsibility: Identify food needs; ensure that food gets to disaster affected areas.
Primary Agency: Food and Nutrition Service, Department of Agriculture.

ESF 12: Energy
Responsibility: Restore power systems and fuel supplies.
Primary Agency: Department of Energy.

ANNEXURE-II

Disaster Assistance Summary
FEMA-1391-DR-NY

January 18, 2002

This information about Federal and New York State assistance programs for the World Trade Center disaster is updated weekly. Please contact FEMA's Information & Planning Section at (212) 680-3694 if you have questions or need further information.

	Applications/Claims/ Registrations Approved	$ Approve
AID TO INDIVIDUALS		
Housing	5,278	$26,506,419
Mortgage and Rental Assistance	1,305	$5,073,186
Home Loans - Small Business Administration	277	$4,272,400
Individual & Family Grant Program	2,154	$3,340,328
Disaster Unemployment	2,238	$4,109,398
Regular Unemployment Since 9/11 (58% total increase over previous year)	52,234	NA
New York State Crime Victims Board	4,899	$5,512,649
Crisis Counseling Grant to State	N/A	$22,726,534*
Food Stamps	32,915	$3,824,663
AID TO BUSINESSES - Small Business Administration		
Business Loans for Physical Loss	396	$24,804,600
Economic Injury Loans	2,215	$203,105,300
AID TO GOVERNMENT AND CERTAIN PRIVATE NOT-FOR-PROFIT AGENCIES		
FEMA Grants for Debris Removal and Reconstruction		
Emergency Assistance from FEMA and Other Federal Agencies		
	TOTAL:	**$972,752,892**

*Review for New York has been scheduled for January 29.2002

Errata

Pg 7, paragraph two, line five: Read factor as factory

Pg 9, paragraph two, line one: Read Near to as Near

Pg 13, paragraph one, line two: Read Gujarath as Gujarat

Pg 23, figure caption: Read Numbers as Number of

Pg 23, legend caption: Read damages strctures as damaged structures

Pg 35, subhead number: Read 3.2 as 3.3

Pg 39, paragraph five, line one: Read stage as spate

Pg 45, paragraph three, line two: Read infrared as infrared bands

Pg 53, table 1B, column four: Read 1.000.000.00 as 1,000,000,000

Pg 63, paragraph three, line three: Read meager as meagre

Pg 90, paragraph one, line one: Read singly as single

Pg 90, paragraph one, last line: Read birterrorism as bioterrorism

Pg 91, paragraph one, line two: Read of the low as of low

Pg 96, last paragraph, line two: Read virsus as virus

Pg 97, paragraph one, line eleven: Read weapon zing as weaponising

Pg 113, slide two, line seven: Read Also has also as Also has

Pg 127, paragraph one, line three: Read flurorine as fluorine

Pg 159, paragraph two, last line: Read discernble as discernible

Pg 162, paragraph two, line two: Read striks as strikes

Pg 162, paragraph two, line nine: Read our this as our forte, this

Pg 165, paragraph two, line thirteen: Read most these as most – these

Pg 167, paragraph one, line two: Read '≤' as more than

Pg 230, paragraph two, line three: Read had with as had exposure to

E-F

The reader is a collection of papers presented by eminent experts during the annual course on disaster management conducted over the last few years by the National Institute of Advanced Studies, Bangalore, for senior IAS officers from across the country. The collective experience of the contributors can serve to generate new insights and methodologies in tackling disasters in the country.

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