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COMBATING NATURAL DISASTERS - ENGINEERS' RESPONSIBILITY

Eur Ing Sarfraz Ahmad

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By

Eur Ing Sarfraz Ahmad[1]

ABSTRACT

Living beings, their habitat, built environment and infrastructure have historically suffered all along due to natural hazards on earth which, when of colossal magnitudes catching us unawares and unprepared, have caused tragic disasters.

The weakness of unpreparedness of society to combat disaster has been highlighted in recent disasters in our region; where disasters due to huge Earthquakes, Tsunamis, Floods, and Storms etc. caused horrendous loss of life, property, livelihood and indeed huge economic loss.

Engineers with balanced analytical approach to problems and solutions can influence policies, planning parameters, and evolve better disaster management techniques. They can build Resilience and Preparedness in Society to Combat Disasters in a better way, through knowledge using science and technology.

The Paper highlights Engineers responsibility to work pro-actively, in local groups at national and regional levels to achieve this capability.

INTRODUCTION

Civilization developed on earth in a fairly consistent manner over the passage of time. There were of course ups and downs due to natural and man-made circumstances, of drought, famine, earthquakes, floods, trading over land and sea routes, wars and disputes, agriculture development, advancement of sciences and technology, industrial revolution and great inventions that charted the history of human development and the built environment.

But all along this path of development mankind had to surmount the hurdles and difficulties caused by natural calamities.

Although universe is in a state of upheaval and change occurring all the time at tremendous speeds and of huge magnitudes, we are stuck to our little earth due to gravity with a protecting umbrella of atmosphere. We do not feel any of these tremendous changes occurring in the universe or notice those that have occurred over millions of years, or are happening now at distances far away or have happened in a time frame measured in terms of millions of light years. Even our knowledge from remarkable pictures of cosmos (Hubble and Space probes) is sometimes old in terms of time in light years.

Stability

We think that we are stable with our feet on the ground towards the centre of the earth and so are our tall buildings and built environment steady in relation to horizontals and verticals of earth surface at that location. [Fig-1] We mainly notice the movements with reference to the sun and the moon, and those of the wind (their storms and hurricanes), clouds, rivers (the floods) and the seas (waves), or tremors (earthquakes) that move us dynamically in vertical or horizontal directions or twists from our stable positions on the earth.

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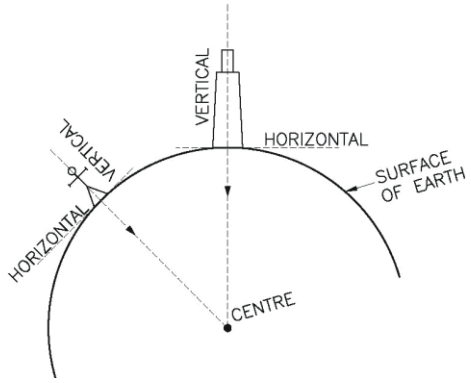


Figure-1:

We live on the earth for such a short span of time as compared to the universe; and we have such a limited memory of record of events or knowledge of history, that we concentrate mostly on our present, and perhaps only a bit more about foreseeable near future. We take the mountains and topography of earth as permanent, in its "present" position.

Forces of nature are often working against us.

Causes of Natural Disasters

Natural Disasters are caused to human habitat and systems because of their vulnerability to abnormal conditions, accidents and adverse situations in the earth; and our inability to thwart, prevent or a weakness to counter the damaging effects of such natural upheavals or hazards.

Our vulnerability is due to our position on the earth, inherent instability, our lack of full knowledge, unpreparedness, and absence of better control over elements.

But engineers & scientists have developed some devices and techniques to save ourselves from the sun, the rain, floods, and natural hazardous occurrences, and collectively developed systems to support each other in drought, famine or other hardships.

Our Knowledge of:

The Earth Structure:

We live, move, eat, build and die on the Earth's upper "crust".

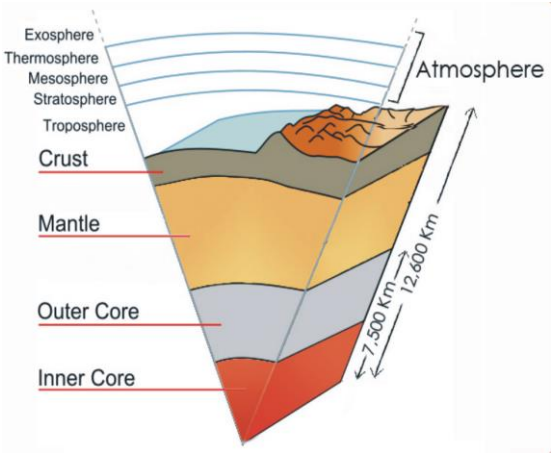


Figure-2:

This crust has a thickness of 25 - 90 km in the land mass area and is thinnest at 6 km under Oceans, on the surface of our Earth which has a diameter of about 12,600 km and approx 400 km thick atmosphere above it. [Fig-2].

This upper crust is sitting or floating on molten matter deep down in core, with an approximate diameter of 7,000 km, pressure upto 3.5 million atmospheres and temperatures upto 3,500^{o}C.

This crust is heterogeneous: has clay, sand, sedimentary rocks, fold mountains, Granitic layer over Basaltic layer and Outer & Inner Core with metals Nickel, Iron etc., in these. The highest Mountains are over 8,500m high and the deepest sea about 11,000 m. There were so many upheavals and drift in the life of the planet, that some of the high fold-mountains like Himalayas were under the sea about 50 million years ago. There is more seismic volcanic activity in the sea than on the land surface.

Although Earth is about 4.6 billion years old, the present habitable situation and temperate climate on Earth has been there for approx 10 million years; and may last perhaps for another 1,000 million years more. There is so far no other known 'planet' where human life could survive or where humans could migrate to.

Life of Earth planet itself is not infinite, it may disappear in less than 10 billion years by natural death, or earlier if a cosmic accident occurs.

Earth's stability in our "present" is temporary, it is held in place by gravity and rotation around its axis and orbit around the sun, which itself moves in the Milky Way in space, and in the larger context along with other galaxies in the universe.

Planet Earth has gone through drastic changes throughout its evolution, as known to science today:

- Extremely Hot – Volcanic activity and
- Extremely Cold – ice ages

Temperature ranges at present can support life on land in most parts of the globe, and we concern ourselves for our near future.

In the known life of humanity; earlier man hunted other animal life for his food and survival, ate plants and fruits etc., and about 10,000 years ago established Agriculture.

Human life span in time scale is like an "Augenblik" on the Earth, which itself is a speck in an infinite space of cosmos. In the vast universe or cosmos our earth is but a "pale blue dot" as described by Carl Sagan[i] and as observed (Fig.3) by Voyager-1 in 1990 from afar.

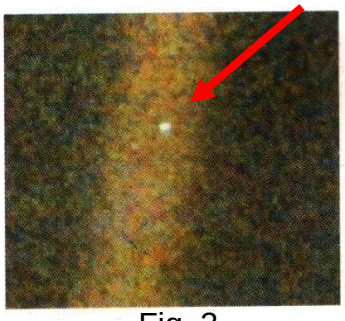


Fig. 3

56 million years ago Co_2 geological emission to atmosphere warmed the earth by 9 – 10^{o}F (Co_2 rose from 1000 ppm to 1500 ppm). It lasted 150,000 years; brought drought, floods, insect plagues, extinction of several species. 9 million years afterwards a huge asteroid is said to have slammed into Yucatan Peninsula of our earth, shattered the earth in shock tremours, and wiped out dinosaurs and several other species.

Changes we observe on Earth in our present environment are:

- Ozone depletion.

- Greenhouse emissions (Gases) / Greenhouse effect / Acid Rain.
- Global Warming, (by human neglect or entrapped methane escaping to atmosphere), Changing Arctic Zones (Ice diminishing & some plant & animal life starting).
- Tectonic Plates Movements / Volcanic Activity.

To forestall Climate Change we must pay full attention to human responsibility for depletion of Ozone in upper atmosphere causing global warming which contributes to natural hazardous situations. While the third world rightly blames the West for merciless activities that generate excessive carbon dioxide and other harmful gases that cause this; global warming is also a geophysical phenomenon, causing melting of arctic ice on a gigantic scale.

Ozone in upper atmosphere restricts harmful UV energy of sun and protects us. But there is a huge amount of solar heat energy as well as, electromagnetic energy which is absorbed in soil & vegetation and sea but part is reflected and part is dispersed. The heat, generated by Forest Fires, Volcanic eruptions, thousands of tons of TNT used in explosives in wars and strife around the world, and of course the steady cumulative effect of fires in hearths of humans, all contribute to global warming.

We are all continuing this warming process but are not prepared to face the consequent hazards. Today the warming caused by burning fossil fuels is bad enough, but if warming continues it could also trigger a release of methane from deep sea and the frozen North, and cause a situation, similar to that which occurred 56 million years ago.

Life on planet earth is vulnerable; at the mercy of enormous forces of nature, and changes on grand scale over time, and is presently exacerbated by the onslaught of climate change.

Mankind has the ability to adapt to hostile nature, and has done so historically, but it may become impossible if the change is too great, and beyond limit of human tolerance.

Population increase on Earth

As civilization progressed – population increased – life expectancy increased with better health facilities, medicines & cures, and living became comfortable with infrastructure development.

Population of humans from a few in number (as we believe in Adam & Eve) to a few pairs of humans and animals (Referring to Noah's Ark and the great deluge) has increased to 7 billion today, which will build up to 9 billion by year 2045 (with urbanization increasing much faster), and who knows how many more humans in just 100 years!

There may soon be "Standing room only", when we shall need much more resources, enormous infrastructure and shelter for many times more in thickly inhabited areas.

All this has also to be safe against natural hazards.

At Present

Civil Engineers today are busy harnessing the forces of nature and building a better world, and in doing so they are blocking rivers, diverting water, bridging over vast areas of deserts and water bodies, flying through atmosphere, cruising across oceans, speeding on land, climbing against gravity and in a race with others are building taller sky-scapers, harnessing energy from wind & tide, gas & coal, nuclear, hydrogen & sun, and developing infrastructure at tremendous costs to enable comfortable habitat for the present population, but are consuming available resources at an ever increasing rate, perhaps not leaving enough for posterity.

The demand of food & facilities keeps on increasing at accelerated rates due to population increase. But our natural resources, sweet drinking water, water for irrigation, land & food producing capability are "limited", and are the largest latent hazard in store for humanity.

Essentials of Life

Our resources being limited, population increasing unabated and with it the demand of resources, there is bound to be horrific scarcity and imbalance.

Pakistan is going to be most affected, with the neighbours that we have and the narrow-minded political neglect in not building water reservoirs like Kalabagh Dam, the wasteful water usage, and the insensitivity to unchecked population increase, sometimes blaming it on the religion.

Natural hazardous occurrences put an increasing strain on whatever resources we have. Major considerations are:-

Water: Water is essential for life – sweet water availability is diminishing, and ground water is found much deeper in ground. There is likely to be a situation of water famine in various lands in 10-25 years, and Pakistan is on the edge already at this time.

All historical human settlements were next to water, rivers, lakes, where now the quality is becoming unsuitable.

The built environment and infrastructure is already inadequate for present population, and quite incapable of sustaining shocks or unchecked increase.

Food: Scarcity and famine may have to be faced; since population growth is more than the earth productivity of food.

Shelter: Population is increasing fast, and there is concentration of population in small areas, life expectancy & longevity is increasing and the number of youth is a big percentage of population in most developing countries, who will require more houses.

Communications: River transport, sea routes, land routes, the passes through the mountains, air-transport will have to be increased. There are congestions already. Highways, Railways and airlines do not need only to be brought back on track, but quantum leaps have to be made to develop these at fast enough pace.

Environment: Environment is getting badly polluted. Will life be sustainable? Must we deplete resources mercilessly leaving these insufficient for future generations? With untreated waste-water rivers are becoming sewers and drinking water and food contaminated and adulterated. Just look at Deg Nullah and river Ravi near Lahore.

Protection from Disease:

Harmful bacteria, viruses, epidemics, Diseases are rampant, like Malaria, TB, Small Pox, Dengue, Measles, Cholera, Typhoid etc. The Health Burden in case of natural disasters increases many-fold in affected areas.

Natural Hazards:

There are innumerable forces hostile to life, and there are persistent hazards of:-

- volcanic activity, lava & ash
- seismissity, earthquakes, tsunamis
- Fire (forest fires)
- drought, heat-waves, sand storms, dust, desertification
- weather storms, hurricanes, cyclones, tornados, fog
- floods, snow-storms
- Landslides or mud flows, river erosion
- rising sea level
- disease / epidemics (viruses)
- Lightning
- scarcity of food, famine

Natural hazards have no borders and are merciless.

Particularly in our neighbourhood and in the Asia Pacific Region:-

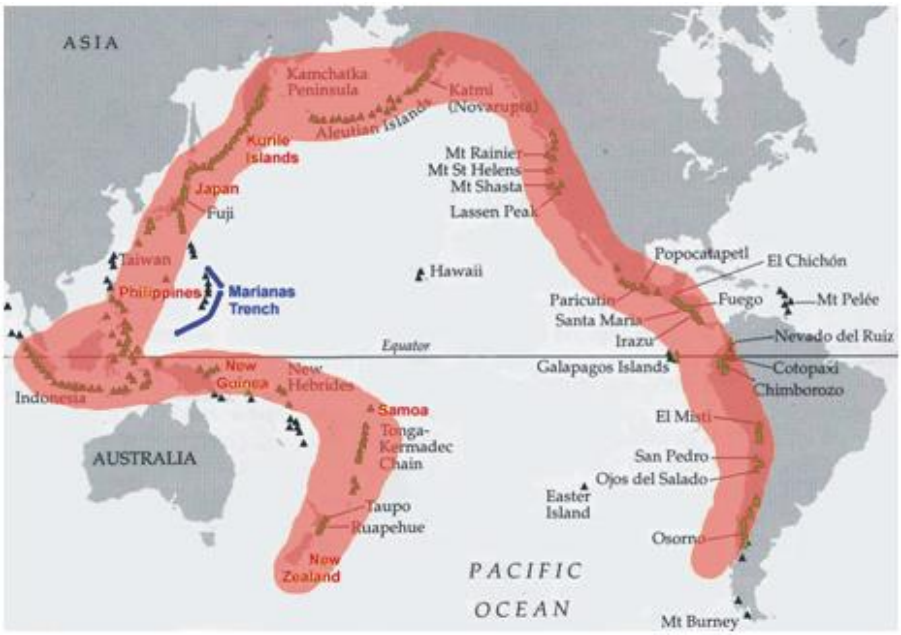


Fig. 4 - Pacific Ring of Fire [ii]

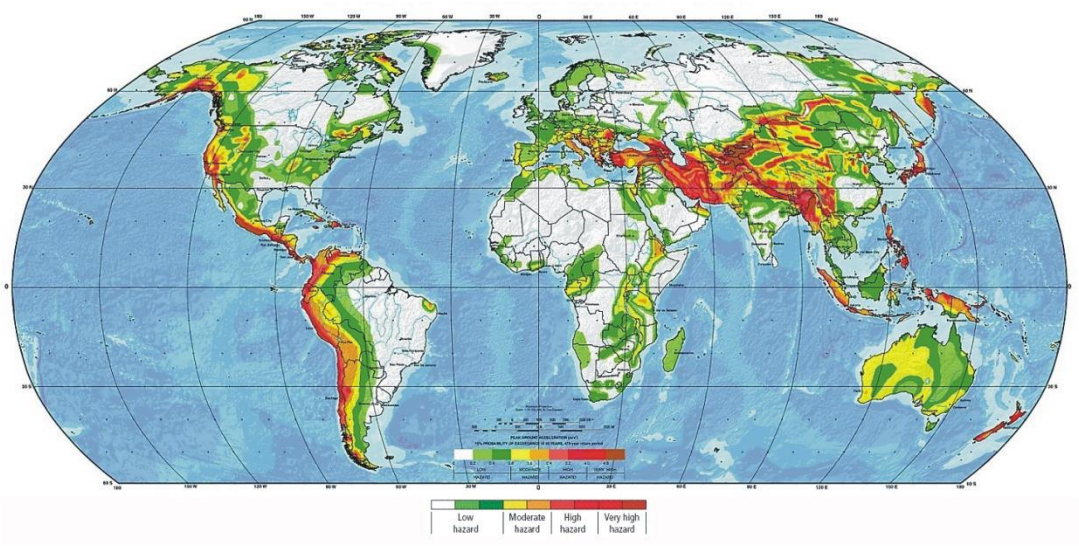


Fig. 5 – Global Seismic Hazard Map [iii]

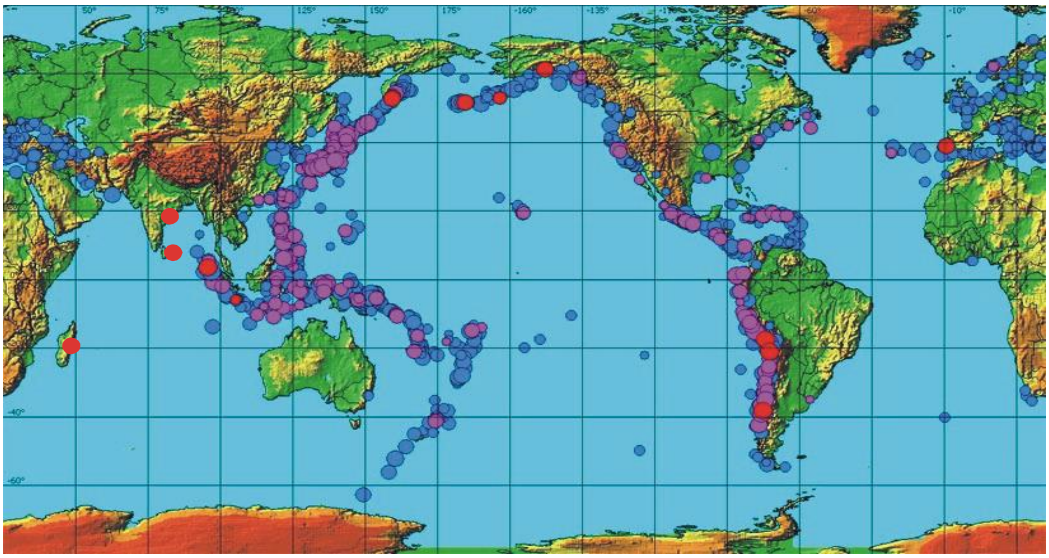


Fig. 6 - Map of Historical Tsunami Sources in the World Oceans[iv]

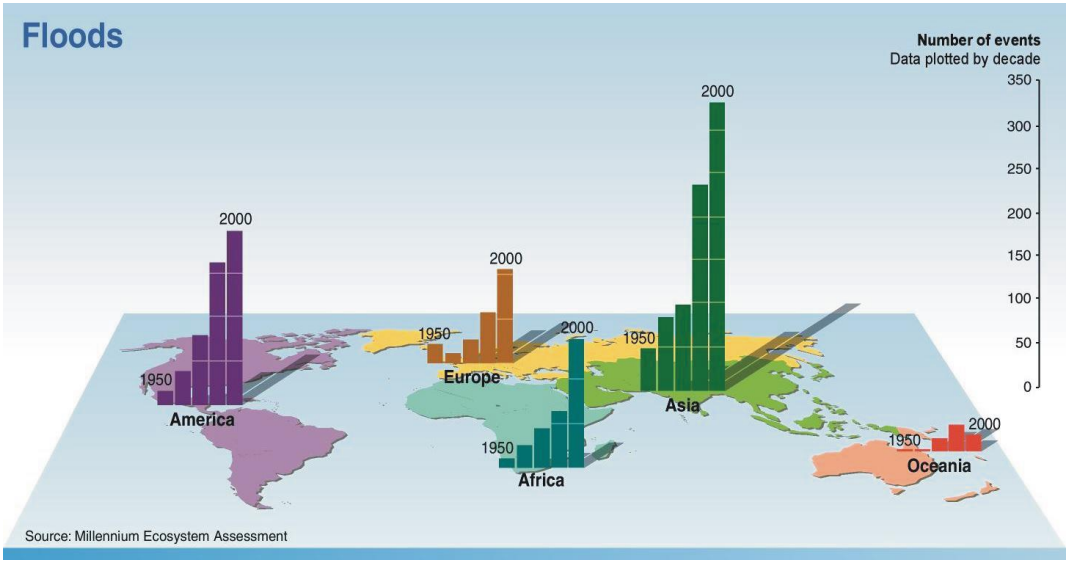


Fig. 7 Floods [v]

Hazards if unchecked may cause:-

- Trauma and create Panic
- Loss of Life (human, cattle) agriculture, plantation & livelihood
- Shock, Psychological loss and desperation
- Loss of property / infrastructure / habitat
- Environmental loss
- Economic loss

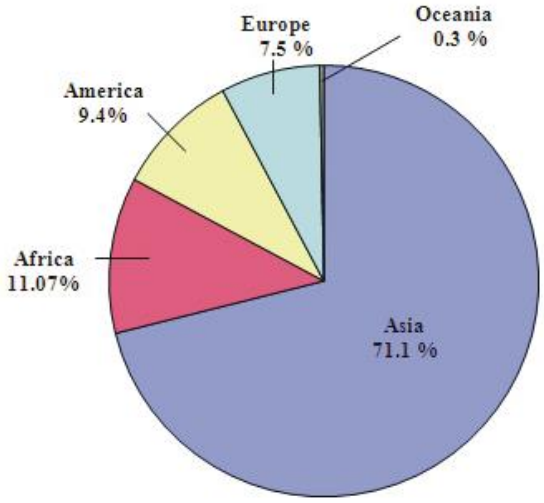


Fig. 8 Regional Distribution of Global Total Fatalities of all the Natural Disasters from 1986 – 2006[vi]

Let us recognize that:

Hazards can become disasters:-

- if they catch us unprepared, without warning

- are colossal unprecedented and beyond any anticipated expectation
- are of sudden occurrence and are not predicted
- are overwhelming, beyond our means and capacity to combat or counter ill-effects
- occur in thickly populated areas with weak built environment
- affect important infrastructure, critical communication systems, housing, environment, multi-rise buildings, built environment, hospitals, schools.
- destroy agriculture, power generation installations, health facilities
- inundate, submerge, uproot, displace population, burn or bury

In most under-developed or developing countries poverty and deficient governance often aggravate disasters, which in turn may cause further poverty leading to increased vulnerability to the risks of disaster.

For existing habitats

Isn't it a worrying situation that:-

- Most habitats were established adjacent to water source, rivers, lakes, springs, oases in desert area, or are near forests that could catch fire.
- Almost half of humanity lives within 100 km of sea coast or sea navigable waterways. 8 of the world's 10 largest cities are on the coasts.
- Most cities are located on or very close to fault-lines, or edges of tectonic plates
- Many cities along sea-shore are not much higher than high tide level. Coastal regions less than 5 m in elevation are in danger of sea-level rise or storm surge disaster [In China such area is = 44,000 Km^2 with a population of over 70 million and in Bangladesh and India area over 20,000 Km^2 and population at risk of 30 million, and many islands like Maldives are not much higher than tide level].

For all New Habitats:

Engineers should ensure that new human settlements are created in safer areas, away from natural hazards risks:

- Away from low lying coastal areas, to preclude disasters due to rise in Sea level and tsunamis
- Away from possible drought areas, deserts
- Away from low areas affected by floods; with safe settlement patterns
- Away from fault lines, tectonic plates edges, seismic areas

But for existing habitats in such areas, and for new habitats, adequate measures are to be engineered to preclude disasters, and society must be 'prepared' to be able to manage the disastrous effects.

We must strive to keep on taking such safety measures to extend life possibility, and sustainability on Earth:

- Till the environment becomes too hostile to support extended life

- Till we destroy our own planet, by our own excesses, abuse and unwise policies about resources consumption, negligence, warfare
- Till population overtakes all possible growth of energy, food and life support systems
- Till an accident in the cosmos destroys our planet.

How can we engineer our way safely & efficiently through calamities / hazards / disasters?

Local, Regional or International Responsibility?

In the Asia Pacific Region countries, a 9.3 M Richter scale earthquake on Indonesian Sumatra sea-floor in 2004 not only caused havoc locally and flattened Banda Aceh, but the resulting Tsunami caused death and destruction along coastlines of Thailand, Sri Lanka, and India and as far as East Coast of Africa. A huge earthquake of Magnitude 7.6 Ms on 8th October 2005 in Northern Areas of Pakistan and Kashmir took a toll of nearly 90,000 and wiped out towns and villages and affected a population of 21 million in Pakistan, India & Afghanistan. Floods in Pakistan in 2010 affected nearly one third of the inhabited country and 20 million people. Floods affected vast areas of India as well. The enormous earthquake of 9.0 magnitude and subsequent 14m high Tsunami in East Coast of Japan in 2011 destroyed Fukushima and badly affected Nuclear Power Stations, even through Coastal Protection walls were in place, but the waves were even higher, and broke the barriers. The earthquake in February 2011 in New Zealand that caused excessive destruction particularly in Christchurch also pointed out our helplessness when disaster struck, and subsoil layers liquefaction occurred.

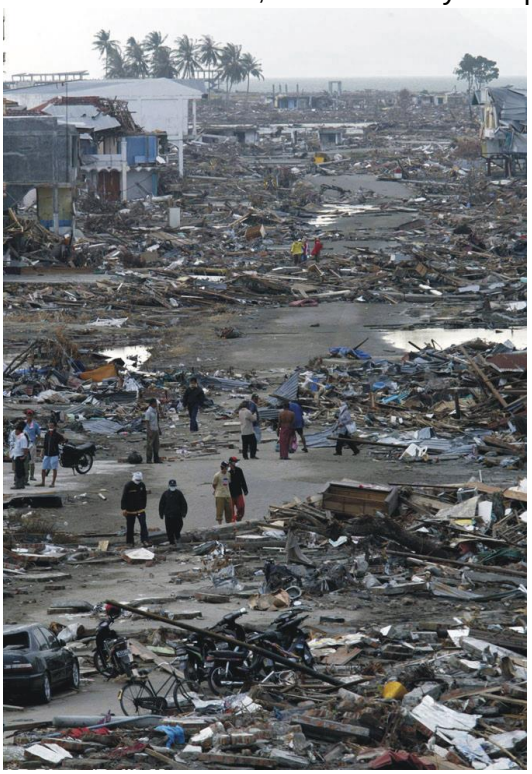


Fig. 9 - Devastated Commercial District of Banda Aceh, six days after the earthquake-triggered Tsunami[vii]

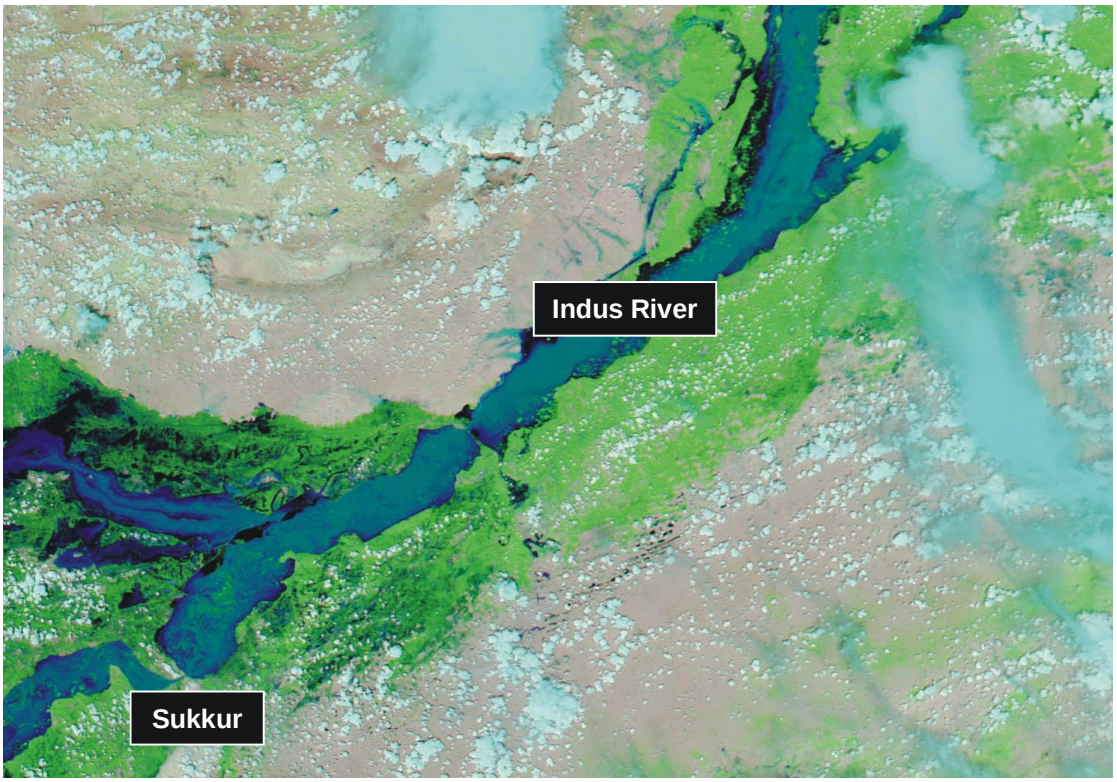


Fig. 10 – Satellite image of Lower Indus River during 2010 Pakistan Floods[viii]



Fig. 11 – East Coast- Japan 2011 Tsunami[ix]



Fig. 12 – Christchurch Disaster in New Zealand Earthquake Feb 2011



Fig. 13 – Villages totally devastated in 2005 Earthquake in Kashmir, Pakistan[x]



Fig. 14 – Huge Landslides obliterated Highway & Mountains in Muzaffrabad, Kashmir[xi]



Fig. 15 - Site of the Margalla Towers Islamabad that collapsed during the 2005 Earthquake[xii]

Natural Disasters are no longer a local problem for one nation, not even Regional but a Global problem, for which all must pool resources, make a database, and work together for combating disasters.

Working together gaining from each other's experiences, the Engineers can develop proper planning to be able to combat disaster effectively.

Natural Disasters, Earthquakes & Tsunamis, Floods and similar other catastrophic events with concomitant colossal losses experienced in the recent years, clearly point out:

- A general lack of preparedness and resilience
- Lack of advance-warning systems,
- Insufficient knowledge, and capability of prediction of the size and intensity of the problem;
- Insufficient planning, available resources, technology, capability,
- Lack of proper guidance or effective Governance
- absence of sufficient rapid deployment capability in rescue or speed in reconstruction.

Developing countries are particularly weak in their capacity and capability to mitigate natural disasters and they lag behind in monitoring systems to be able to do predictions, and are scientifically and technologically less educated and they definitely need external; regional or international help, in addition to gearing up their own act, involving their own community and improving their knowledge, preparedness, ability to developing a resilience in the systems.

Examples of Lesson Learnt in 3 Recent Disasters:

Event	Lessons Learnt
1. EARTHQUAKE 08 October, 2008 Affected Pakistan, Kashmir, India, Afghanistan Magnitude: 7.6 Ms Death Toll: 80,000 Injured: 106,000 Population affected: 21 million	• Preparedness could have mitigated the extent of damage, death toll by 80%, property and economic loss by 40% • No alternate communications, road and accessibility were available, vast areas of total destruction of human habitat could not be reached. • Most construction was on risky slopes and landslide-prone areas. Constructions on the very edge of Rivers went down. • Huge Landslides buried houses, blocked rivers. • No Seismograph or Recording Station or data was available in the area; need to establish these close to fault lines. • No effective warning system in place. • Stringent Seismic Building Codes and enforcement are required. • Better Construction methods & Standards, use of more suitable materials required. • General lack of knowledge, awareness, education and training.
2. TSUNAMI 26 December, 2004 Banda Aceh, Indonesia Caused by Seismic Event below ocean bed Caused waves of 1 m, travelling hundreds of Km/hr on reaching shallow waters were 10m high. Affected India, Sri Lanka, Thailand, Malaysia, Kenya, Tanzania. Death Toll over 100,000, Population affected over 10.0 million.	• Lack of Preparedness to react speedily. • Although Scientists immediately knew of the earthquake in sea floor, there was no way of sounding Tsunami alarms. • Need to improve warning systems (similar to Pacific Ocean), an alert system to enable people to escape to higher ground. • Need Planning controls on development & buildings and human settlements along coasts prone to high-tide Tsunami. • A great international Relief effort undertaken; within a period of 10 days, total global Civil donation of USD 1.8 billion, very helpful. • International awareness & informed society is a necessity. • Improvement in construction types and stringent codes and their enforcement is vital.
3. FLOOD 2010 Pakistan Death Toll: over 5,000 people	• Lack of Preparedness to handle a disaster • Advance warning system found inadequate • Lack of cooperation by India on information sharing • Lack of environmental control on deforestation • Lack of control on human settlements in “Katcha” areas within flood-prone low areas along rivers.

Event	Lessons Learnt
Number of homes damaged: 1.9 million homes Animals: Area inundated ~ 1/3rd of inhabitated area of the country Population Affected: 20 million	• Need to upgrade traditional local advance warning systems historically practiced in the area, and about shifting families and livestock to higher ground in time. • Need to build much more water storage capacity in dams. • To build shelters on higher ground. • To strengthen dykes, protection bunds and levees, and build new ones. • Clearance of obstructions in flood escape paths. • Need through Government agencies, proper control of relief goods storage, distribution of food, shelter materials, medicines, seeds, agricultural & livestock support. • Need to control Corruption at all levels in flood relief work.

Lot of relevant work has been done on the subject by international agencies, the United Nations & World Economic Forum.

UNESCO emphasized a global culture of **'Preparedness'** and necessary shift in paradigm from disaster relief, (post-disaster reaction) to pre-disaster (disaster prevention) enlisting science and technological advances into disaster preparedness and mitigation measures, and to develop disaster resilience through knowledge, education & public awareness. They started a campaign "Disaster Risk Reduction Begins at School" and pointed out that education & public awareness effort is successful only if local people and community are totally involved. [11]

The disaster mitigation & recovery efforts should become an integral part of country's civil defence system. In crisis the relief and recovery programme is best handled by the Army due to its ability to mobilize, and its training to take control in adverse circumstances.

The First World Conference on Disaster Reduction (WCDR) in 1994 had adopted Yokohama strategy for a safer world and Plan of Action on prevention, preparedness and mitigation of disaster risk.

The First Asian Conference on Disaster Reduction (ACDR) in September 2005 in Beijing in wake of Indian Ocean Tsunami of January 2005, adopted Beijing Action for Disaster Risk Reduction in Asia.

The Second World Conference on Disaster Reduction in Kobe Japan made "Hyogo Declaration" for Action in next decade on 5 commitments of the framework, making disaster a priority, knowing the risks and taking action, building understanding and awareness, reducing Risks & Preparing for Risks and strengthening emergency services.

In November 2007 the Second Conference of ACDR's Delhi Declaration called upon Asian countries to implement 5 priorities adopted in "Hyogo Framework", to cooperate when making national development strategies, legislations etc. and to speed up early disaster warning systems.

World Economic Forum emphasized the importance of public & private sector abilities to collect knowledge, expertise and capability and contribution of financers, Insurances & banks and demonstrated how this 'Financial Preparedness; and proper use of Media enables reduction in Life and Economic Loss, and results in faster recovery.

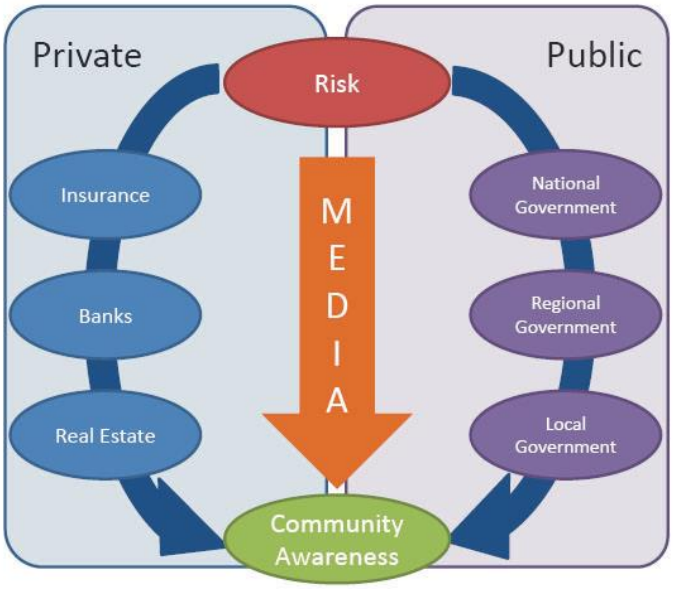


Fig. 16 Role of Media for both Public & Private investment for Risk Management[xiii]

Stages of Disaster Management:

- Emergency Response
- Relief Measures
- Recovery
- Reconstruction & Rehabilitation
- Mitigation, Assimilation of lessons learnt & improved Preparedness

A General graphical representation / progression relating to effect of disaster is presented in Fig.17.

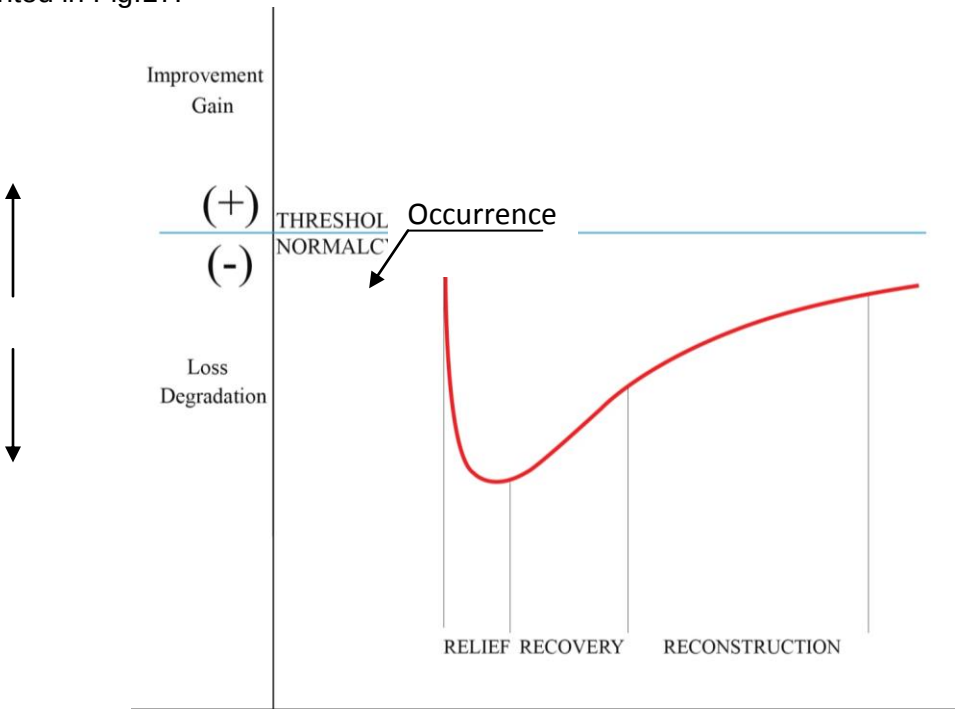


Fig. 17 – Effect of Disaster

ENGINEERS' RESPONSIBILITY

We can do very little about natural hazards, but we can reduce loss; casualty, undesirable effects, and resulting economic loss by preparedness measures and prudent action, for which Engineers must come forward and take responsibility.

We also must realize that many of the World's disasters could have been greatly mitigated with proper fore-warning, planning and preparation, and the cost of this 'preparedness' could have been much smaller than the cost of emergency relief and recovery efforts, and indeed that of long-term reconstruction.

How can Engineers act to preclude or at least minimize disasters / risks?

Engineers must assume responsibility and plan proactively.

To succeed Engineers have to:-

- Understand Risks
- Be warned beforehand of likely disasters
- Be prepared beforehand to combat
- Plan policies and Manage Disaster Remedies
- Influence politicians, policy makers to put things in motion at the right time.

The Loss:

The loss of human life and their homes, animals, plants, vegetation, crops, means of livelihood, infrastructure, means of communications, and the resulting economic loss, in a catastrophic natural disaster is often enormous and tragic.

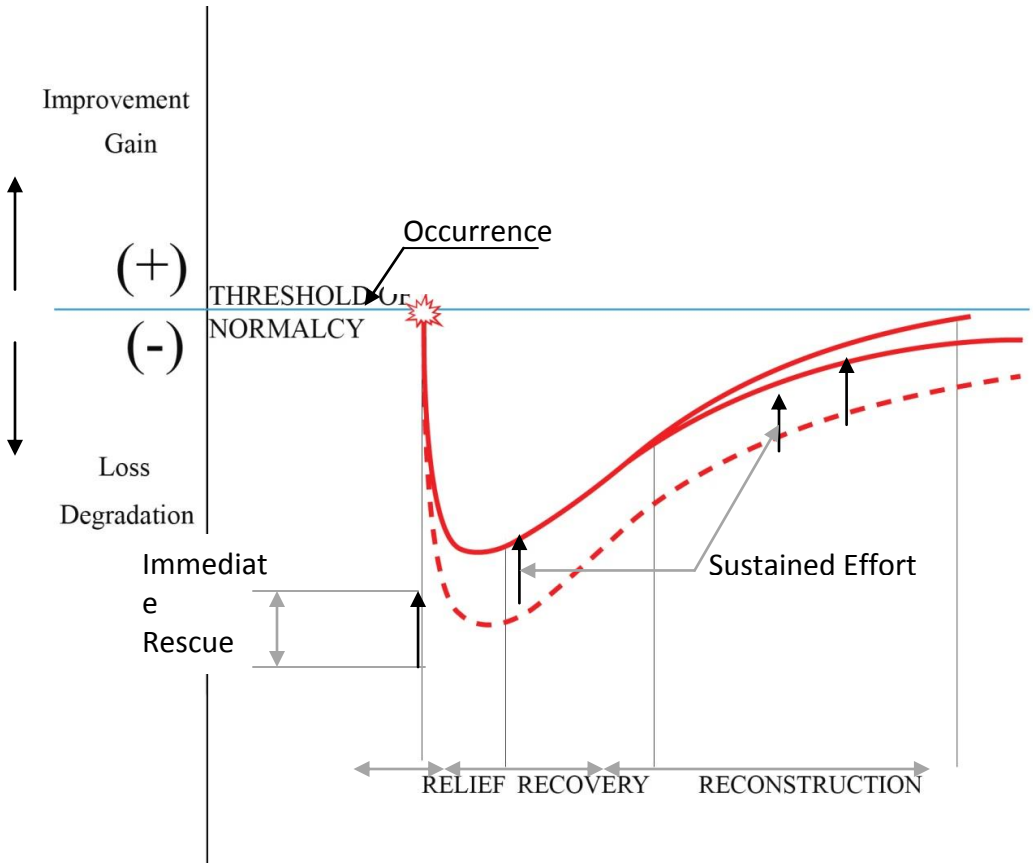
The effort:

It therefore needs an equally intense concerted effort and a focused priority plan for combating; relief and rescue, recovery and reconstruction, and a sustained effort particularly in the reconstruction phase.

Engineers' Input:

Engineers are trained with rational thought and have developed analytical minds. Brought to a high academic level, awareness of problems with broadened visions; when confronted with technological problems Engineers have the inherent ability to innovate and improvise and deal with these. Moreover when armed with a Prepared Plan, and pre-developed information, and resilience in the Community, they can be even more effective.

It is often witnessed in case of such tragedies that a heroic effort is made by individuals, groups and national agencies, of bringing rescue and relief to the suffering with food, tents, blankets, clothing, medicines and blood donations, aided by international, government and UN agencies, airlifts of relief goods, aid in setting up shelter and medical camps by friendly countries and Red Cross and Red Crescent and groups like Red-R, in the "Rescue and Relief Stage" and donations, medical and financial aid provided for the reconstruction and rehabilitation work, and often actual re-building of human settlements; hospitals, schools and infrastructure in affected areas in the 'Recovery Phase' (see Fig.18).



ecovery from Disaster

But this effort is sometimes too late after the event and is not properly organized or takes too long in getting organized, and is often costly.

ENGINEERS' ROLE

Engineers' role in inculcating in Community the Preparedness to combat disasters is for both pre-disaster and post-disaster stages, and is their professional responsibility.

Needless to say that Engineers will have to work together with the civic society, the Government and the local & international agencies, the NGO's, insurance companies, banks and the United Nations, and in synergy with other outfits and programmes working in Disaster Management locally, regionally, and world-wide.

This is in line with the spirit of framework commitments adopted by the comity of nations in the "Hyogo Declaration" for Action during 2005 – 2015 in Kobe Japan in the Second World Conference on Disaster Reduction[xiv].

The work has to be done by Engineers in local groups at national level to prepare to combat natural hazards applicable to the country specifically. The Asia Pacific Region is confronted with more frequent and catastrophic natural hazards than in other regions, that cause big loss of life, property and economy.

Some Natural Disasters in Asia Pacific Region countries
Estimated Severity of major Hazards (Prioritized 5 high – 1 low)

Country	Storm	Flood	Drought	Earth-quake	Tsunamis
Australia	2	3	4	5	1
Bangladesh	4	5	1	2	3
China	3	4	1	5	2
Hong Kong	4	3	1	5	2
India	1	5	2	4	3
Indonesia	3	2	1	5	4
Japan	3	2	1	5	4
Korea	4	3	1	5	2
Malaysia	3	5	1	4	2
Nepal	3	4	2	5	1
New Zealand	3	2	1	5	4
Pakistan	2	5	3	4	1
Philippines	3	4	1	5	2
Sri Lanka	4	3	1	2	5
Thailand	4	5	1	3	2
Taiwan	5	4	1	3	2

Fig. 19

The Engineers will have to build around them teams of volunteers, young enthusiastic members of civic society along with experienced knowledgeable seniors, associating with the engineering organizations and academia from universities. They will as a first measure to define the potential risks in the country and to formulate essential steps necessary for an effective plan of preparedness and mitigation of risks, and then take practical steps.

Planning of Preparedness

First and foremost for success is “Planning” to counter the hazards or disasters.

Preparedness is vital: Being prepared to combat disasters is most definitely something that everybody has to be, for the very reason that we can never know exactly when these occur. The saying “better safe than sorry” is the best policy to be adopted. However, if we want to be prepared to deal with the wrath of nature, we have to start doing so immediately!

Disaster Preparedness: Planning involves knowing, forecasting and taking precautionary measures prior to an imminent threat, as well minimizing the adverse effects of a hazard through effective preventive actions, well-planned rehabilitation and recovery measures to ensure the timely, appropriate and effective organization and delivery mechanism of relief and technical assistance following a disaster.

It is done through two stages; pre-disaster and post-disaster.

PRE-DISASTER STAGE:

1. Knowledge

- Knowledge of Risks:

  Risk may be defined as[xv]

  Risk = f (hazard x vulnerability)

  Knowledge of resultant risk involved in any hazard is essential. A natural hazard becomes a disaster in a complicated way but humanity, built environment and society are vulnerable to risk largely due to unpreparedness.

- Knowledge of types of natural hazards that can be disastrous; their frequencies, magnitudes and geographical areas in the country that are predictably under threats of such hazards, their likely impacts on natural and built environment and on facilities; structures, infrastructure and population, is essential and must be assimilated and stored in a Knowledge Bank.

- Understanding of each type of Hazard through case studies, local or in other countries, and historical records of earthquakes, Tsunami, floods, storms, drought, population growth and habitat patterns, is necessary in devising suitable remedies and strategies to minimize the adverse impact.

2. Assessment / Forecasting:

- The Engineers shall collect and absorb available data and promote establishment of more advanced warning and predicting systems through ground Stations, Flood Control systems & monitoring further data by satellites around the earth with earth-observation systems for hurricanes, storms, floods, and earthquakes observed in real time through seismographs to, enable early warning & even forecasting of hazards like earthquakes & tsunamis.

- The Engineers shall recognize and update traditional preparedness strategies and existing warning systems practiced in hazard-prone areas.

- The Engineers & Scientists shall then be able to forecast events based on their knowledge of correct information shared by countries and institutions and gathered at observation stations through research and innovation at local, national and regional levels.

- The risk assessment techniques should be dynamic, and Engineers shall review, modify and update the information on regular basis.

3. Hazard Plans & Hazard Maps:

- Hazard mapping shall be done by accurate identification of Regions of country vulnerable to different hazards, Preparation and publishing of Maps charting such Hazard Areas of different risks. Such Hazard maps should then be shared locally and regionally staying abreast with the latest weather trends and seismic activity occurring in the country's regions, and to stay prepared for any such occurrence.

- Hazard-specific Plans should be prepared by analyzing events that have taken place, available data, case studies of different hazard affected areas and by making a matrix of likelihood of occurrence of each hazard and its criticality area-wise.

- Lessons learnt from each event shall be recorded, analysed and antidote formulated.

- All hazard Combat Plans need to be rehearsed and Engineers shall convince community of the importance of these hazard plans. User friendly publications and guidelines in local languages shall be made available, shall be taught in schools, colleges and in groups and trades, and explained to community at large. Special training workshops and periodic drills for communities most vulnerable to disaster shall be conducted.

  An example is presented in Fig. 20

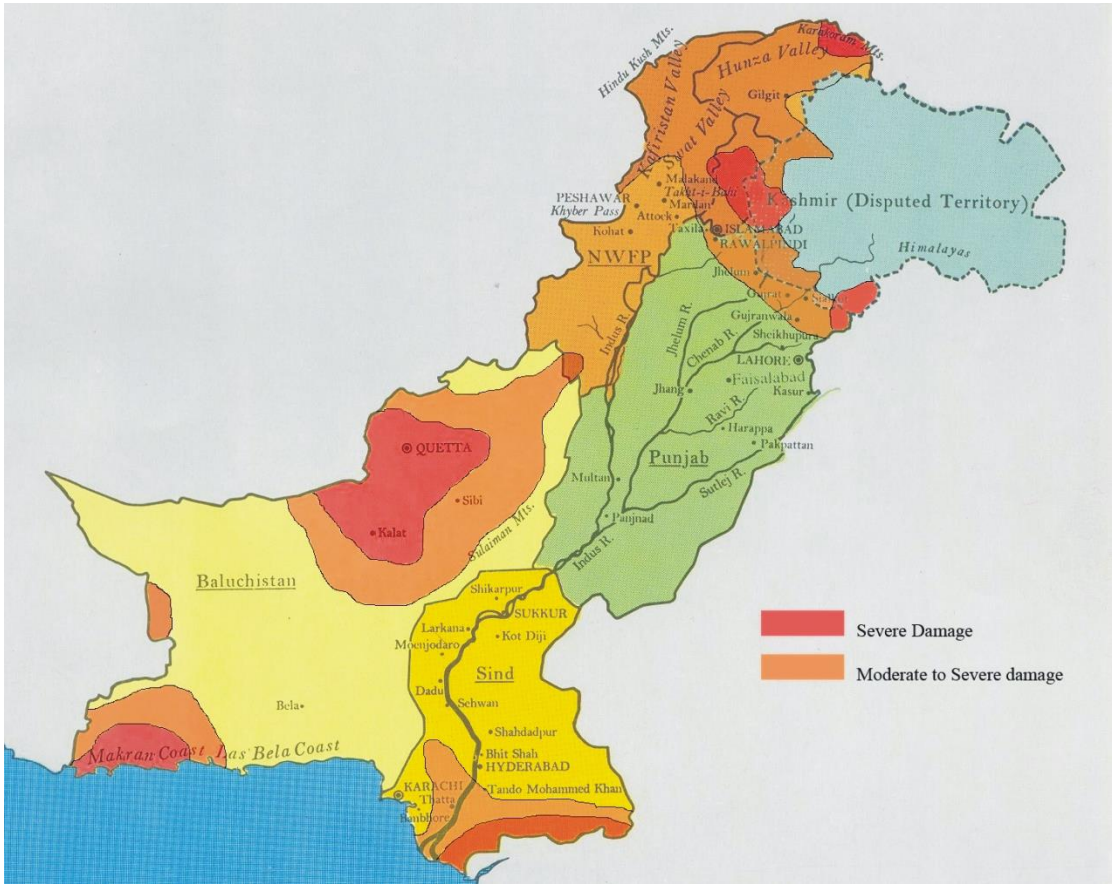


Fig. 20- Earthquake Hazard Map of Pakistan

4. Warning Systems:

- Engineers shall participate with relevant organizations in educating people in the community about the warning and alarm signs so that they know what each alert sign / signal means and what to do next.
- Education starting from schools should enlighten the public about hazards, hazard warnings, and what to do in case of occurrence of an event.
- Metrological and geological departments should continuously be able to asses risk(s) from oncoming hazardous occurrences, to establish an effective warning system and alerts time-table.
- Warning systems at airports and emergency declaration at hospitals, news broadcasting on radio and television (and displaying assigned coloured flags at high points in remote areas) locally, regionally and internationally shall be pre-programmed to inform people

around the globe of the occurrence of calamity, up-to-date status and imminence of danger and risk.

- What to do immediately after signals of warning, will be dependent upon the type of Hazard, e.g. Earthquakes often result in high physical damage to infrastructure, buildings and life; Tsunamis can cause floods, destroy coastal regions, agricultural land and livestock, Floods and Hurricanes can destroy buildings and damage utilities. Hazard Plans and warning systems should therefore be hazard-specific and prioritized in order of importance and their risk-potential.
- With detailed Hazard Planning, Engineers can play their vital role of uplifting the threshold of all living beings and inculcate in them a "Resilience", by being prepared and ready for a hazard, enabling communities to choose most suitable alternative, and combat any disaster with minimum toll on life and loss of property by establishing Rapid Deployment Forces systems.

5. Publicizing / Propagating

It is necessary to propagate and publicize the latest updated information, precautionary measures and guidelines to combat specific hazards that are likely to become disasters, relating to each disaster-prone area; as well as the developed warning systems for public.

Engineers can help in doing so through Government's Information and Education Departments, Public Relations sections of Disaster Risk Management organizations and local Governments, and through schools, mosques, churches and places of worship, and indeed through effective use of Media.

For more informed society, certainly for younger generation, the Role of Media is very important and their message very effective. It is effective through the popular tools everyone today uses, including:-

- Mobile Phones – the latest tool
- Cell Service providers
- Cable TV providers
- Dish TV providers
- Information on Line
- Newspapers, Magazines
- Social Websites like Twitter & Facebook etc.

6. Mitigation strategies:

At local and regional level mitigation efforts should focus on physical / structural mitigation works, land-use planning and building Design Codes, Engineering & Construction Standards, selection of materials suitable for resisting the the hazards, the principles and their economic incentives. This involves awareness, resource management etc.

- **Awareness:**

"While many people are aware of the terrible impact of disasters throughout the world, few realize that this is a problem that we can do something about"

– Kofi A. Annan, UN Secretary General 2004.

- Generally Communities can be made safer through awareness, information, advice, guidelines, printed material, media facilities and campaigns involving the community.
- For this purpose Engineers at graduate level joining local Institutions shall be trained to further generate awareness in public at large, specifically educating and training communities in vulnerable areas to minimize the effect of hazard.
- Each country needs to formulate medium and long term natural disaster mitigation policies for adoption in their areas based on occurrence of specific disasters emphasizing the importance of science and technology based decision–making and establishing a platform of effective communication of these best practices.
- Workshops, research programs, information sharing and exchanges with other Engineers shall ensure that not only new knowledge is shared but also the traditional practices, case studies and "learning from mistakes concept" are considered while planning awareness policy / strategy.

- **Resource Management:**
  - Mitigation strategy should also include all of the activities that are carried out prior to a catastrophe in order to facilitate use of available resources, delivery of relief and rehabilitation in an appropriate and effective organized manner following a disaster. This would involve all players in this field more prominently Government Departments, Civil Defence, Rescue Departments, Disaster Mitigation organizations, and the Army.
  - Financing for resources should be done through Insurances, Banks, UN agencies, National Budgets & International funds to provide resources globally to help when local resources are insufficient.
  - Funds should be reserved locally and suitable materials should be stored locally, regionally and globally ensuring quick access and delivery in case of an emergency.
- **Design Codes Review:**
  - When planning new infrastructure, cost effective techniques should be considered in initial stage of Planning in Design of Infrastructure with particular attention to their robustness and flexibility in crises, and in construction of buildings the form, materials and types that are ductile and sway rather than break under the stress of an earthquake, and are able to resist flood waters, and allow tides to flow through in lower level, depending upon the area.
  - Building codes shall be reviewed, and updated for various zones to reduce the occurrence or impact of possible disasters so as to prepare sites or local specific buildings designs.
  - It is imperative that the codes of design and construction are enforced even in remote areas, which is possible only through public awareness and strict control of implementation.

- Proper land-use control need to be exercised so that it reduces danger of life and property loss particularly in case of floods and Tsunamis by not allowing construction on or near water bodies, or below a certain highest tide or flood level, and all constructions to be suitable.
- All new development activities should be only initiated in areas where a detailed study of the region is carried out by qualified engineers, geologists & scientists, and problems of land-slides, liquefaction potential of soil, etc. are addressed.
- Engineers shall develop techniques / technology for enhancement of infrastructure, such as technologies for improvement of soft soil and high-performance structures etc.
- Engineer's shall take Structural mitigation measures to make a significant impact of earthquake safety. Engineers shall review, and if necessary recommend amendments to building bye-laws to incorporate more stringent provisions in codes for design and construction for relevant zones / areas.
- Codes should be reviewed in terms of updating them continuously for construction of structures with high natural disaster resistance.

POST-DISASTER STAGE:

Planning for Rescue, Relief and Rehabilitation

It is particularly important to plan well to combat hazards in the Post-disaster Stages of Rescue, Relief and Rehabilitation fully catering for the needs relevant to type of disaster, its severity and location. The three stages are:-

1. **Rescue Phase (Generally lasts 7 - 15 days)**

   The rescue operation starts with local residents, volunteers, and available facilities immediately after the occurrence of a disaster, and is later supported by trained and skilled staff from the Rescue operation teams and often trained army teams. These activities are often complemented by non-governmental organizations (NGOs). International Relief Teams arrive in the later stages, usually after a couple of days, depending on accessibility, and political relations with the country. The rescue phase usually lasts for the first couple of weeks after a disaster while the rate of survival of trapped victims is high.

2. **Relief Phase (Generally lasts 1 - 6 months)**

   The relief phase follows either immediately after the rescue phase or often simultaneously, and may last between one and six months depending on the severity of the hazard, the resources of the government and means of communication and transportation to the affected areas. Government is usually the central point, followed by additional resources from NGOs and international organizations.

3. **Recovery & Rehabilitation Phase (May lasts for several years)**

   During the recovery phase, social and other infrastructure is restored and the economy revitalized. The recovery, rehabilitation / reconstruction phase typically starts at the end of the relief phase and depending upon the hazard may last for several years. The short-term plans for the recovery process are clearance of debris, building housing units, and restoration of lifelines and infrastructure, while the long-term objective is to build a safer and sustainable livelihood and better infrastructure. Past experiences show that these

efforts are sustainable only with community-government partnership, while the role of NGOs and international organizations is reduced after a certain period.

Objectives of Engineers Plan for Combating Disasters:

Overall objectives of Engineers should include plans for:

- Restoration of economy, productive capacities of affected areas and re-establishment of basic social services
- Rehabilitation and reconstruction of the infrastructure services and reducing the vulnerability to future disasters and risks
- The reconstruction programme should be considered an opportunity to set improved standards rather than rehabilitate to previous state only.
- Record of carefully assessed specific needs for rehabilitation and reconstruction of a hazardous occurrence.
- Systematic plan of Human Resource needs and deployment for specific function in the Reconstruction Programme.
- Transparent management of donations and supplies given by agencies without corruption, pilferage or waste
- Learning from feed-backs, updating of "Preparation" and "Action Plans" for possible future disasters, their better management and physical rehabilitation.

EXECUTION OF ENGINEERS' PLANS THROUGH GOVERNMENT DEPARTMENTS

The Engineers Plans for Preparation to face the hazards and to mitigate and combat the Disasters can only be executed through the Local, Provincial and Federal Governments integrating the Civil Defence Set-up, the Flood Control, Meteorological; Food, Health, Rescue and all other departments, the NGO's and indeed with the involvement of Army (with its training and combat resources) and international agencies, financial arrangements and logistic support.

Comprehensive Plans shall therefore be developed to combat disasters through Government Departments; Observation Stations and Warning Systems established and programmed to provide advance effective warnings. Rapid Deployment Forces shall be set up with adequate equipment, stores and resources.

It is Engineers' responsibility to show to the Society the importance and urgency of "Preparedness", and how it would benefit all in reduction of loss of life, property, livelihood, and the resultant reduction in economic loss in a shorter span of time.

This effect and benefit is represented Graphically (in Fig. 21), which shows the normal situation as well as over-lapping the situation with proper "Preparedness". Through proper 'Preparedness' the harmful effect of hazard is reduced, the whole curve is pushed "up" towards (Gain) and to the "left" in terms of (shorter time), suggesting a much smaller economic loss (Area under curve) and a quicker recovery and reconstruction (shown by arrows).

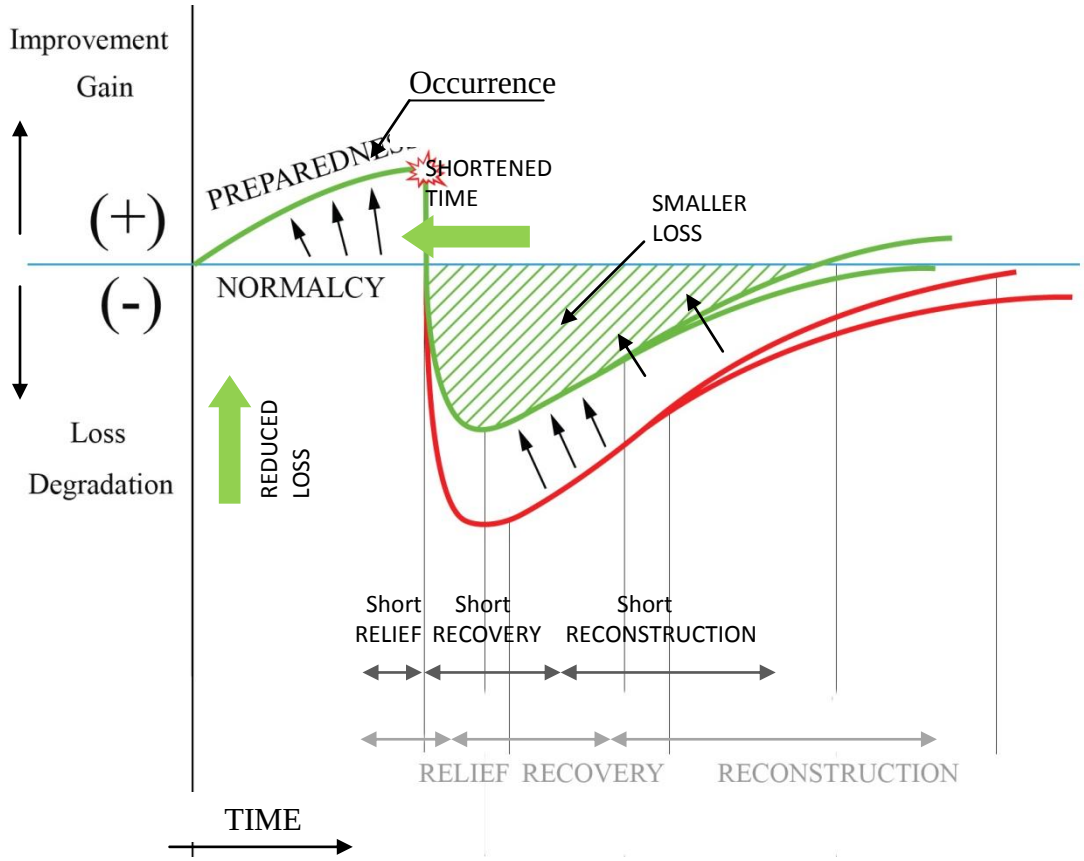


Fig. 21 – Benefit of "PREPAREDNESS" in Recovery & Loss

CONCLUSION

The paper has highlighted the great importance of "Preparedness" in combating the disasters with much reduced losses. Engineers with their trained analytical approach can 'prepare' the communities in the pre-disaster and post-disaster stages to reduce their vulnerability to risk and to build in a resilience to withstand and to combat hazards more effectively.

Engineers have to equip the society for this purpose with the essential ingredients of knowledge and information, advance warning and alert systems based on science and technology from within the country, from other countries of the Region and indeed from the World, and prepare it for better Relief, Recovery and Reconstruction, thereby ensuring smaller risk of hazard and reduction in loss of hundred of thousands of lives, property, livelihood, infrastructure and indeed billions in economic loss in each disaster.

Armed with Preparedness all this will be achieved not only with less damage but also in a shorter time frame.

It will require a concerted effort of all involved stake-holders, the Community, the Government, NGO's and international agencies. It is Engineers' responsibility to work proactively and show the way, and stick to the noble cause with tenacity and perseverance.

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