Rajendra Kumar Bhandari

Disaster Education and Management

A Joyride for Students, Teachers and Disaster Managers

Springer

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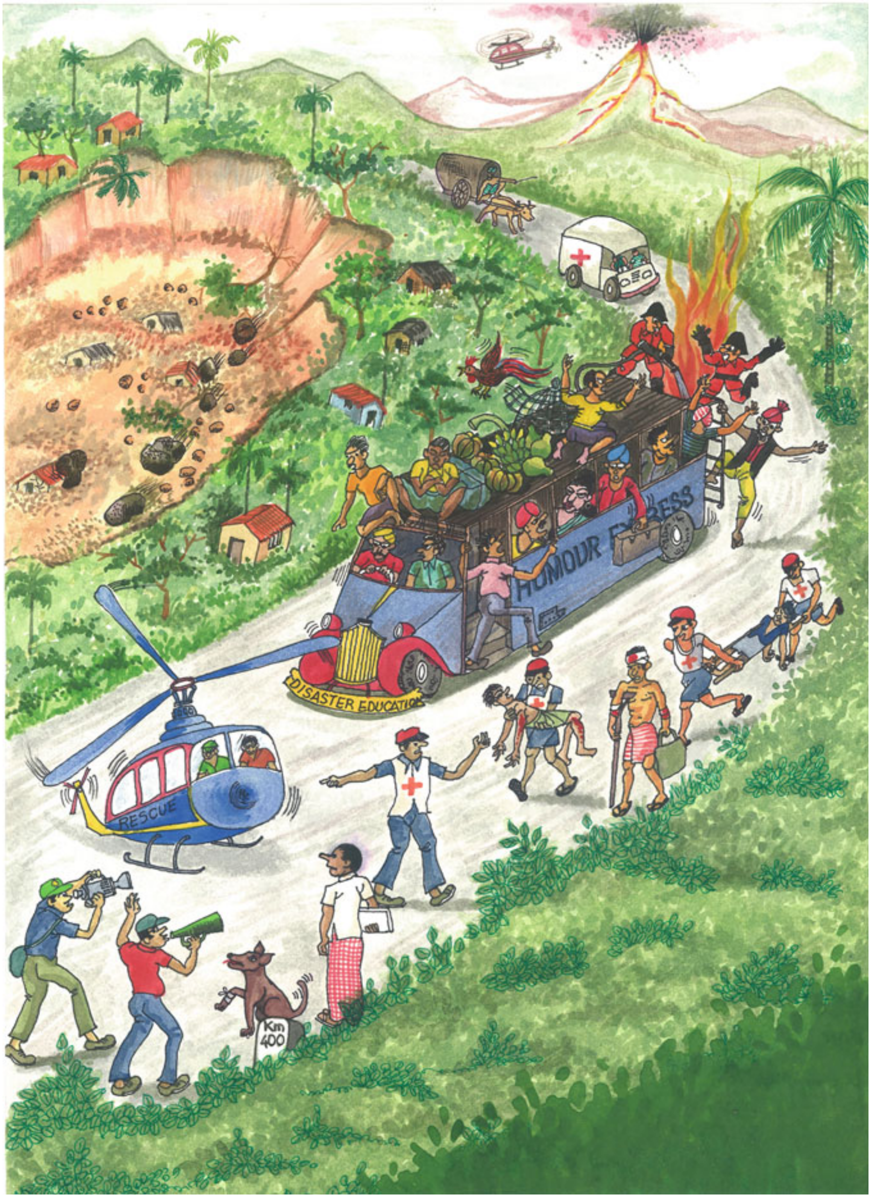
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A Joyride for Students, Teachers, and Disaster Managers

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This book on Disaster Education and Management a joyride for students, teachers, and disaster managers is a humble offering of the SSS Foundation to Shyam and Sushila−my revered parents, and to Sneh−my loving sister. Even decades after they have gone, stories of their lives remain as fresh, unforgettable, and hugely inspiring. Their mission was to live for others and to bind the world around them with the glue of everlasting relationships.

The author

Preface

What is the use of a book without pictures and conversations?

Alice in the Wonderland

This is a typical book providing us with a pleasant mix of information about disasters with cartoons, illustrations, and quotes. The author, Dr. R. K. Bhandari excels in presenting disaster education in a captivating manner. The book is not a burden to read but provides a lot of fun along with education. I agree that it gives a joyride through the huge arena of a variety of disasters. There you find coverage of a biblical array of disasters like earthquakes, tsunamis, volcanoes, landslides, cyclones, tornadoes, floods, fires, and blizzards. The book guides us through lessons in disaster management, public response, and disaster preparedness. Safety procedures are constantly evolving and Dr. Bhandari has presented the latest procedures.

Introducing scientific and technological developments into disaster management is of value. Disasters cause enormous losses to the economy. It should be the global endeavor to develop and adopt new technologies to improve prediction of hazards and disasters. Above all, education is needed to create greater public awareness about the threat, the scourge of disasters pose. The book is a praiseworthy attempt in this direction. I hope that this book will reach a wide audience.

S. K. Joshi
Formerly, President, Indian National Science Academy
Director General, Council of Scientific and
Industrial Research and the Secretary to the
Government of India, New Delhi

Acknowledgments

The book in your hands would never have seen the light of day without the author's direct exposure to disasters enriched by an unending feed of a whole range of information from dozens of excellent papers, reports, and books. Every effort has been made to adequately acknowledge all sources of information which infuse life into the book and further effort will continue to rid the book of the lapses, if and when detected or pointed out.

Information and permissions can be acknowledged but I do not really know how to adequately acknowledge the insights and support that I have received from a large number of my teachers, my colleagues, and my students. My most profound thanks go to Prof. S. K. Joshi, a former President of the Indian National Science Academy, for his insightful comments as also for writing the Preface to the book. Likewise, I have no words to thank Prof. D. V. Singh, a former Vice President of the Indian National Academy of Engineering, for his painstaking review of the manuscript and exceptional comments. I am particularly thankful to my old friend—Mr. Sunil Fernando, an acknowledged artist who made and baked the cartoons in the heat of my thought-furnace—always with a smile on his face, and to Dr. Biman Basu for the editorial assistance.

The book owes a lot to the legendary Cartoonist Ranga for his cartoon of Mahatma Gandhi drawn on my autograph book with a few masterly strokes of his pencil. What was it if not a wonder to make a simple cartoon speak volumes about the greatest man of our times without saying a single word? It is from this simple but powerful cartoon that I picked the *semantics* of the book for which I thank Ranga.

I thank Dr. Arther C. Clark, Dr. R. Rubik, and Dr. Muhammad Yunus for the gifts of three subject-related thoughtful messages recorded in my autograph book. In fact we must all thank Dr. Clark for his message *Do not panic*. These three simple words have the power to save a million lives a million times! Dr. R. Rubik, the Inventor of the famous Rubik's cube, wrote *be curious forever* and Dr. Muhammad Yunus, the Nobel Laureate wrote "keep trying." When the three messages are read together, no further message may be necessary!

I would like to most sincerely thank Pradeep Nilanga Dela, Diyawadana Nilame of the Sacred temple of the Tooth-Relic-Sri Dalada Maligawa of SriLanka for permission to reproduce the famous painting of the Dalada procession that included the participation of the British rulers, as also for the related plaque which speaks of the magic of Buddha's tooth relic. It was the exposition of the Tooth-Relic which created an intense flood to wash away a sticky drought. The assistance received from Nirmala, Wijewickrama, Brigadier Udayanta Wijeratne, and Major Chandratillake, the Administrative Secretary of Dalada Maligawa in obtaining the permission is thankfully acknowledged.

The author thanks UNICEF for the permission to use one of their original cartoons which made it possible to highlight the ultimate joy of freedom from disasters. Thanks are due to the Editor-in-Chief of Media Transasia India Limited, especially to Murad Ali Baig, for permission to use three cartoons from his article published in January 2001 issue of the Swagat Magazine. Permissions from India Today for a cartoon published in its issue of 6 March 2006 and from Hindustan Times for their Salt Pepper Cartoon published on 2 August 1998 are thankfully acknowledged. An Arun Inamdar cartoon from his book of cartoons published by the Indian Institute of Technology, Mumbai has been reproduced with his kind permission.

The book has received acclamation from reviewers even before it is published. I am particularly grateful to Dr. Wolfgang Eder and Dr. Eduardo de Mulder of Earth Science Matters, The Netherlands; Dr. Alexander Strom, Moscow; Prof. Renato Eugenio de Lima of Brazil; Dr. D. V. Singh, former Director, Indian Institute of Technology, Roorkee, India; Mr. J. C. Pant, former Chairman of the High Powered Committee of the Government of India on Disaster Management, Prof. Robin Chowdhury of Wollongong University, Australia; Dr. P. G. Dhar Chakrabarti, the Founder Executive Director of the National Disaster Management Institute, New Delhi; Mr. N. M. S. I. Arambepola, Executive Director of Asia Disaster Preparedness Centre, Thailand; Prof. Vinod Sharma of Indian Institute of Public Administration; Prof. Chandan Ghosh of National Institute of Disaster Management, India and Prof. Hideaki Marui of Niigata University, Japan for very encouraging review remarks.

Last but not the least, I would like to thank Prof. Mahendra Bhandari, Mr. Saurabh Bhandari, Ms. Avantina Bhandari, Master Amol Mendonca, Mr. V. K. Mathur, Ms. Anjana Singhwi, Mr. Shambhoo Kumar, and Mr. Rahul Sharma for their helpful assistance throughout the development of the book. Most of all, I thank my wife Mrs. Meena Bhandari for her understanding and endless patience.

The Author's Hello to Readers

Education is an ornament in prosperity and a refuge in adversity, said Aristotle centuries before *adversity* began to hurt humankind so hard as it does now, especially in the world of natural disasters. Had Aristotle been alive today, perhaps he would have regarded *disaster education* as our best hope and mightiest weapon to *reign-in* disasters, on the way to safety. It is paradoxical, however, that the more we have come to know about disasters and their management since the times of Aristotle, the more our fear and curiosity of *knowing about them* have grown. While humankind, by its very nature, continues to strive hard to unravel the mysteries of the unknown, a lot can be achieved in the meantime by putting *the known knowledge* to effective use in comprehending, preventing, and managing natural disasters. Simply speaking, disaster education lies at the heart of disaster risk reduction, management, and safety.

Disaster education is meant for everybody and therefore, sadly enough, it is on the do list of nobody. The irony is that although the subject is hugely critical to the survival of humankind as a whole, it continues to dodge the human imagination most of the time. There are numerous reasons for this. Many people do not see natural disasters as a today's problem because they are overly busy fighting the fire of day-to-day problems of life which rob them of the time, urge, or energy to even consider what might happen or hurt tomorrow. After all, natural disasters have come and gone for centuries on end and humankind still survives; and God-willing, it will continue to do so. At the worst of the times, people do get some transient pain in their hearts which only fleetingly weeps for the victims as and when disaster occur. Is it not true that most of us raise our hands up in despair and take comfort in hiding behind the age old adage that what cannot be cured has to be endured? All this is slowly but surely changing for safer times.

We now see a beam of hope in the disaster-fearing but education-awakened populace and in the inherited virtue of the *service-beyond-self*. Additionally, the good news is that an all-out war against disasters has broken-out worldwide and the threats of disasters are no longer being taken as catcalls of local concern. National governments across the globe and disaster-related international agencies are left with no option other than to educate, equip, and empower their respective peoples. They know that safety will continue to elude people if they are not empowered to help themselves and continuously build on their capacities and partnerships.

This book is expressly written for students, teachers, and disaster managers because they are our best hope for a safer tomorrow. For this hope to brighten as we move on, we need good teachers to ignite the young minds and enlightened disaster managers to serve as role models. Senior citizens, community leaders, social workers, media personnel, bureaucrats and others, including those averse to the very thought of reading will also find the book useful because it is illustrative and inviting.

No book howsoever well written can ever replace good teachers, because good teachers not only live in the hearts and minds of the students but they also influence generations still unborn. It is, however, equally true that no teachers, howsoever great, can excel what disasters themselves come to teach us in the live laboratories of nature. Unlike the conventional classroom education, natural disasters put us to the test first, and teach lessons afterward. And they characteristically hit us at the weakest of the spots with stunning accuracy. Worse still, when a natural disaster strikes, we are often caught napping in utter disbelief, virtually without the foggiest clue of what to do and how best to come out of the crisis unharmed.

It is for this reason that the book draws on both knowledge and experience and offers a joyride into the world of hazards through a simplified teaching–learning process, with less of teaching and more of learning. This is because most students would love to learn without actually being taught.

Since students in schools often come from diverse backgrounds and speak different languages and since every natural disaster throws up challenges which are unique, the only way to fire their imagination is to give them curiosity and excitement of learning. Once that happens, nothing further would be required for the rest of their lives. Informal teaching and self-education through well-illustrated popular publications often prove to be far more rewarding than the conventional textbooks-based classroom learning.

The main challenge before us is, therefore, to re-engineer and innovate *Disaster Education and Management* programs for students, teachers, and disaster managers so as to make them purposeful, substantive, and self-stimulating. If we can make humor embrace learning, the learning itself will become a joyride for self-education. Inspired by the fact that a single picture is sometimes worth a thousand words,[1] an attempt has been made to add humor through more than 200 original cartoons and illustrations. A few of them have been imported to give added smiles to the book, and nurse its soul.

The scope of coverage of this book is, by choice, selective. It is not meant to be a treatise on the specifics of *Disaster Education and Management*, or a manual. It is long enough to cover the subject and yet short enough to sustain the interest of the reader. The author will be most grateful if any inadvertent omissions and deficiencies are brought to his attention via e-mail: rajmee@yahoo.com, both for value addition, and corrective action.

[1] Cartoon1. *Source* Cartoon by Ranga from the author's autograph book.

Please enjoy the book. Your feedback will be your generous gift toward raising the world's most powerful army of students, teachers, and disaster managers to free the world from the wrath of disasters. Indeed the time has come to recall Goethe's famous couplet, "whatever you can do, or dream, you can begin it."

New Delhi, 19 April 2013 R. K. Bhandari

Motivation

The author's motivation to write this book is also fueled by the famine of student-friendly, teacher-worthy, and practice-oriented books on the subject of *Disaster Education and Management* despite the knowledge explosion and the burning need. In the context of disasters, mere knowledge of disasters, howsoever complete, is of little use unless it comes with a feel of what disasters mean to mankind and how human ingenuity can prevent them. The most essential approach leading to a disaster-free world is lessons in nonviolence against nature and a teaching–learning process that arouses curiosity.

We think of nonviolence in action when we see the above cartoon of Mahatma Gandhi by Ranga. Similarly, we should be able to visualize a disaster-free world after we succeed in unleashing the limitless power of nonviolence against Nature. Ranga needed just a few masterly strokes of the pencil to make the cartoon of Gandhi speak volumes without uttering a single word. The author, likewise, saw the possibility of arousing curiosity in the readership by blending the text of the book with the power of simple cartoons.

The Dream Destination

لما كانت الحروب تتولد في عقول البشر
ففي عقولهم يجب ان تُبنى حصون السلام

"It is in the minds of men that the defences of peace must be constructed."

Peace and disasters can never coexist and lasting peace will continue to elude us so long as mother Earth is not freed from the shackles of disasters. Nature has given us the grandeur of majestic mountains, the patience of gorgeous rivers, and the perfumes of the fascinating flora and fauna. In return, we have defaced Nature by robbing its mountains of their vegetative cover, rivers of their purity, and fauna and flora of their heavenly charm. As though all that was not enough, we have also robbed the future generations of their legitimate right on the planet of which we are supposed to be the caretakers. The reckless assault on mother Earth is primarily because of the endless greed in the minds of men. *It is therefore in the minds of men that the defenses of peace must be constructed.*[2]

There was a time when earthquakes, landslides, and floods were infrequent visitors or at their worst, unwelcome natural hazards. Today, these very natural hazards invariably strike as disasters in retaliation to the mindless human violence against Nature for narrow short-term gains. History is replete with examples that whenever we assaulted our mountains, landslides appeared, slope erosion increased, and the ensuing battered landscape paved the way for bigger disasters. Whenever we blocked rivers and diverted waterways to the point of abuse, retaliation was seen in the fury of floods, and in the ensuing widespread deluge and devastation. Whenever we violently acted under the garb of development, a letter

[2] The author was moved daily by this profound message prominently displayed at the entrance of the UNESCO Building in Amman, Jordan while serving UN-HABITAT in the aftermath of war in Iraq.

of invitation to disasters was signed. The end result in all the above cases has been self-inflicted pain and injury due to disasters, which were chiefly man-made and rarely natural. If we do not mend our ways even now, nothing majestic, grand, or novel about mother Earth will remain for posterity to see, other than in the picture books of history!

The author was the first to raise the slogan for a disaster-free India.[3] That mission will be accomplished only when India dreams of a disaster-free world. To many of those with whom I have spoken in classrooms, workshops, seminars, and conferences, the dream of a disaster-free India was like building castles in the air or at best a wishful thinking. In response, I often quoted Henry David Thoreau who said that "if you have built castles in the air that is where they should be. Now put the foundations under them." Let the task of raising foundations to the castles be thrown as a challenge to the young minds as work-in-progress, in the coming generations. It will not be long before we collectively endorse Eleanor Roosevelt's message *the future belongs to those who believe in the beauty of their dreams.*

Disaster education is like a GPS-directed vehicle which should be programmed to take us to our dream destination. Our endeavor to dream big and aim high, and our inner urge to live in harmony with Nature will quicken our pace. Clearly, the current approach to *Disaster Education and Management* by business as usual will need innovation in our ideas and a deep sense of commitment to the perceived change and innovation in change management. We need to realize that disaster education is not just acquiring of knowledge about disasters, but it is about igniting the young minds and planting in them the seeds of safety. Disaster education is also not a destination that ends with university degrees and diplomas but is an unending, exhilarating journey that begins even before entering schools. We cannot achieve disaster education by merely bringing about cosmetic reforms in the teaching–learning process and by loading the students with new books, manuals, and standard operating procedures.

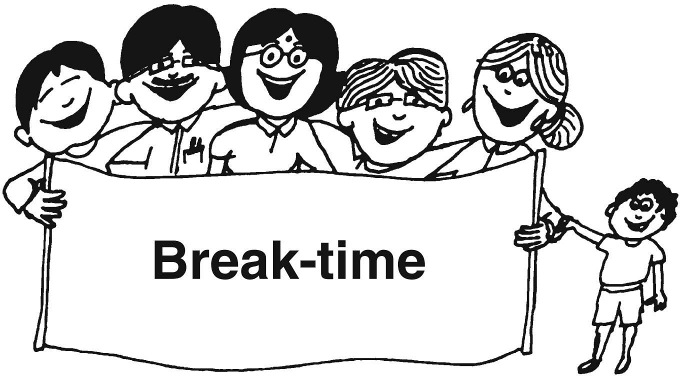
All we must do is to ignite the imagination of the young minds and for sure, one day, they will deliver us lasting freedom from the wrath of disasters.

[3] Bhandari (2001).

Why should we remain the prisoners of disasters and continue to suffer like this? Let us vow to jail disasters instead, build a disaster-free world, and so realize the dream of our forefathers.

Bravo. We did it. We did it. We did it. At this defining moment in the life of our mother Earth, let us resolve to live in harmony with nature and bid the final goodbye to disasters.

The idea leading to the development of the above set of two cartoons came from the original masterpiece published by UNICEF, although in a somewhat different context. The permission by UNICEF for use of their mother poster cartoon is gratefully acknowledged.



Break-time Question 1: What according to you should be our final goal, our end-ambition?
Answer to Break-time Question 1: Let our goal be a disaster-free world.

"Sarve Bhavatu Sukhina
Sarve Santu Niramaya
Sarve Bhadrani Pashyantu
Ma Kaschit Dukhabhagbhaved"

(*Sloka from ancient Indian literature*)

Translation: Let all be happy, let all be healthy, let all be safe, let the sorrow not come in the life.

The dream destination

Reference

Bhandari RK. Destination: disaster-free India, The 23rd Sir Rajendra Nath Mookerjee memorial lecture. Institution of Engineers: India; 2001.

Contents

1 Disaster Education: The Silver Bullet

Abstract

Disaster education is the sharpest weapon of hope in our united, nonviolent, and long drawn but seemingly winnable war against disasters. It sells the dream of disaster-free world and leads us to the culture of safety through the passage of scientific enquiry, strategic planning, capacity building, quick thinking, proactive synergistic preventive action and swift response. It creates self-motivated champions of nonviolence, peace, and safety sanctified by vision, wisdom, and deep sense of universal responsibility to transform disasters into opportunities for building a safer world. The chapter outlines the objectives of disaster education, its scope and its architecture, and shows the way forward.

Contents

Vision

Education is not worth its name, if it does not teach us to dream big, aim high, and act for the greatest good of the largest number with humility and compassion. Likewise, disaster education is not worth its name, if it does not teach us to dream safety, be fearless in the face of danger, and use every disaster as an opportunity to build a safer world for today and tomorrow. In a real disaster situation, a thin line of wisdom may be enough to separate life from death. Disaster education gives us not

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just a line but the whole beam of that wisdom to not only save lives amidst odds but also conduct our affairs in a manner that enhances the safety of others. The door to disaster-free world opens through the corridor of nonviolence, safety, and peace.

Disaster education is a must for creating well-informed, safer, and resilient societies determined to defeat disasters in every possible way. In parts of the world where disaster scenarios are dreadful, resources are limited and people are deprived of disaster education, the task of building resilient societies is even more daunting. The wide disparity across the digital divide—between the rich and the poor, the young and the old, and the healthy and the handicapped—makes it impossible to think of a standard or a single common approach to impart disaster education within a static framework. A multilevel mix of formal and informal education may be needed to suit the diverse backgrounds and the divergent needs of people from region to region. The only thing that remains common is the importance of nonviolence and need to grow the *culture of preparedness and safety*.

Main Objectives

Objective 1: *Disaster-education should charge communities to realize the dream of disaster-free world through proactive united action, strategic thinking, capacity building, and spirit of scientific enquiry. Infact it should sell the dream of disaster-free world under all circumstances.*

The dream of disaster-free world will remain an empty slogan, if we do not genuinely believe in the beauty of that dream. If each one of us can look-after our individual safety without threatening the safety of others, it may not be difficult to imagine a world free from disasters. Collectively we can achieve much more, Fig. 1.1. We have advantage of living in *a global village* blessed with enormous power of science and technology and an unprecedented global resolve for collective global action. Every milestone of achievement we lay on the road to disaster-free world (Fig. 1.2) should boost our resolve to pursue our goals with a missionary zeal. The day will not be very far when we will succeed in building disaster risk-resilient societies living in harmony with Nature and growing the culture of safety in the process.

Objective 2: *Disaster education should create self-motivated champions of peace and safety. We need them in plenty because messengers of peace alone can create ambience in which, attitudinal changes in human beings can take place. "Since the wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed."*[1]

Disaster-free world will be a reality if we see it in our minds first. Let us recall Bob Proctor who once said, "If you see it in your mind, you are going to hold it in your hand." The reckless assault on the mother Earth fueling natural hazards is primarily because of our mindless acts resulting from the endless human greed.

[1] Reference: UNESCO constitution.

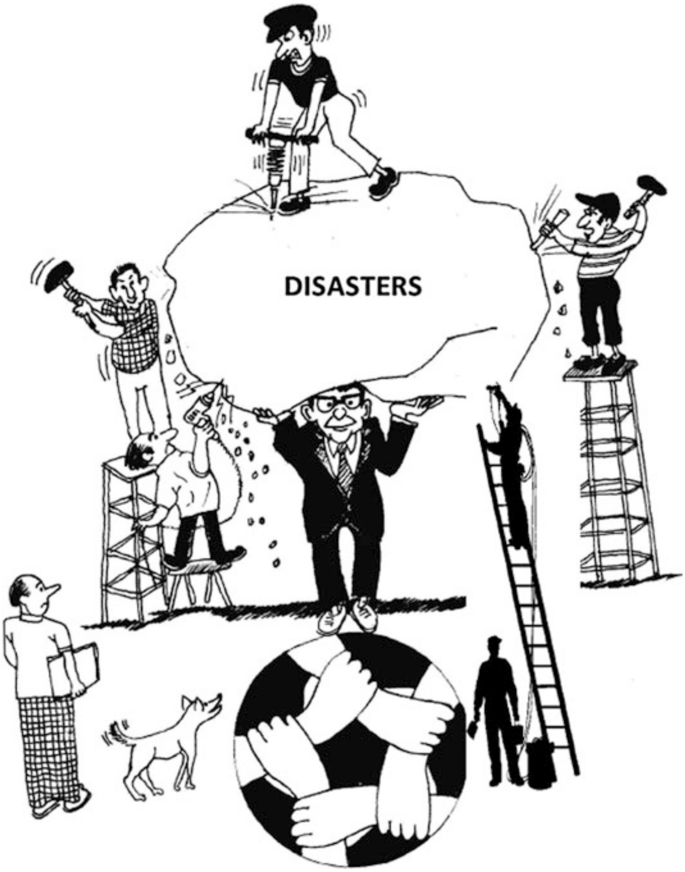


Fig. 1.1 Disasters are a neck-breaking headload on each one of us. Let us resolve to act singly and collectively using every tool in our bags to remove that headload and leave behind a safer world as a gift of our generation to the posterity

It is in the human minds that the greed grows and the plans of assault on the nature get hatched for narrow gains. It is precisely for this reason that we need education that can change such mindsets to a new set of value system, by introspection, self-realization, teaching, and practice. The new value system must necessarily stem from the idea of nonviolence in thought, speech, and action.

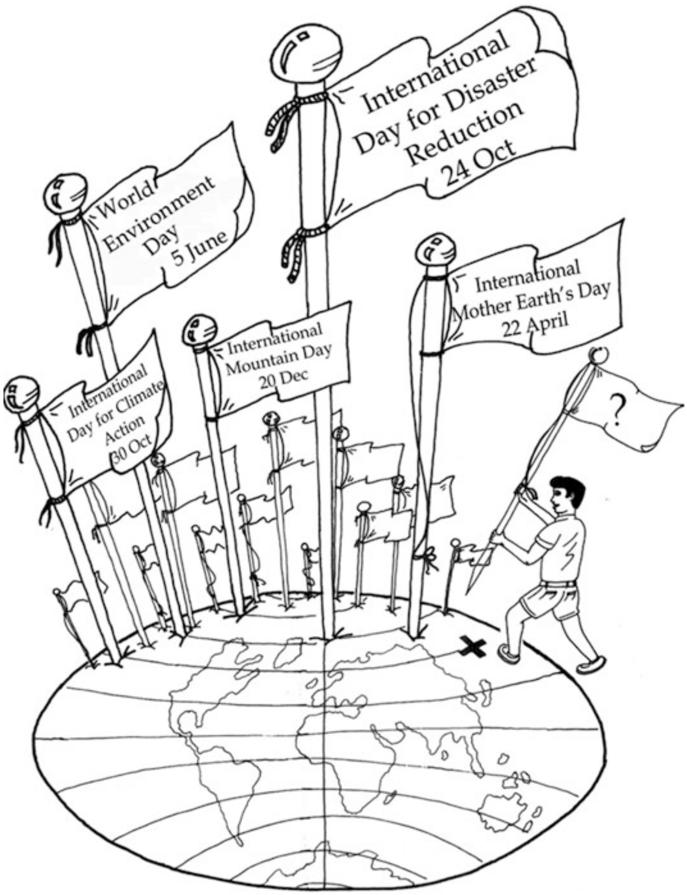


Fig. 1.2 Events such as the Mother Earth's Day are milestones on the road to disaster-free world. Whereas the efforts of this kind must continue unabated with renewed vigor, the freedom from disasters will be possible only if our celebrations are not ritualistic and every day, for example, we live Mother Earth's Day, both in letter and spirit

Man is the creator of problems we face today and man alone can solve these, said Neha Gupta, a school girl through her prize-winning cartoon (Fig. 1.3). According to Gil Stern "man is a complex being: he makes deserts bloom—and lakes die." We need education which will make us turn deserts into lush green forests and dead lakes into the water bodies of heavenly bliss. It is easy to destroy in minutes what nature may take centuries to build. By change of the very mindsets for the better, we can achieve exactly the opposite. Now is the time to act. According to Shakespeare, "*there is a tide in the affairs of men which when taken at the flood, leads on to fortune.*"

Fig. 1.3 The above cartoon is the prize-winning work of Neha Gupta, a student of class XI of the Montfort Secondary School in New Delhi, India. Presumably she was inspired by the UNESCO Charter, according to which "Since the war begins in the minds of men, it is in the minds of men that defenses of peace must be constructed." The analogy seems perfectly in order if one were to say that since war against disasters is to be seeded in the minds of men, it is in the minds of men that the dream for a disaster-free world must be planted

Objective 3: *Disaster-education should inculcate, grow, and nurture in us a deep sense of universal responsibility. Also, it should inspire and motivate generations to leave the world, safer than inherited.*

The quest for freedom from disasters and the sense of universal responsibility are very closely coupled. It is apt to recall Dalai Lama, who while addressing the Parliamentary Earth Summit (Global Forum) of the United Nations Conference on Environment and Development said, "I believe that to meet the challenge of our times, human beings will have to develop a greater sense of universal responsibility. Each of us must learn to work not for his or her self, family or nation, but for

Fig. 1.4 Will you teach your children what we have taught our children that the Earth is our mother. What befalls the Earth befalls all the sons of the Earth. This we know: the Earth does not belong to man, man belongs to the Earth. All things are connected like the blood that unites us all. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself

the benefit of all mankind. Universal responsibility is the real key to human survival. It is the best foundation for world peace." Since preservation and protection of mother-Earth is a universal responsibility, disaster-education should spread *realization* of the fact that "*we do not inherit the Earth from our ancestors; we borrow it from our children*"[2] (Fig. 1.4). Let us also spread the message of U.N. Secretary General that "*through unity of purpose, there is no limit to what we can achieve.*"[3]

War against disasters is winnable. All we require is the political will of governments across the globe matched with untiring effort, building of partnerships, pooling of resources, leveraging of capacities, and a great ambition to succeed.

Objective 4: *Disaster-education should free our minds from the perennial fear of disasters and instead regard disasters as invaluable opportunities to learn from them, and to plough back that rich pool of knowledge and experience to prevent or avert future disasters*.

[2] Largely regarded as an American proverb, some dispute the origin.

[3] *Source* Address of the UN Secretary General to the African Union Summit in Addis Ababa delivered on 29 January 2007.

Disaster management done by the book following standing operating instructions seldom benefits from the amazing power of inner human potential because most people are not even aware of their strengths, not to speak of the synergy of strengths. Variability in the human virtues of grit, courage, determination, patience, and maturity modulates their respective responses in a crisis situation. Sometimes people even when spared by a disaster are known to die of trauma or fear. In the very same crisis situation, people directly in the line of fire could survive because they were fearless and unruffled even in the face of danger. Unleashing of inner human potential sharpens our intellect, comprehension, and analyses, and gives us the ability to develop capacities and systems to foresee disasters and deliver safety even under impossible conditions. Very few of us realize that disasters also bring opportunities.

Freedom from fear is usually human beings' highest attainment on way to ensuring their personal and collective safety. One can work wonders if one's brain can be tapped to its full potential even in the face of danger. It is a highly complex organ weighing less than 2,000 g. Packed with billions of neurons making trillions of connections, it is capable of imagining and simulating complex scenarios, and questioning everything including the established laws of the universe. After evolution through millions of years of time, today human brain is capable of providing solutions to some of the most intractable problems on the Earth, natural hazards included. It is, therefore, important to invest in training of human minds toward achieving freedom from fear simultaneously as the external effort is made in terms of planning, capacity building, early warning, and quick response.

Objective 5: *Disaster-education should give us the wisdom to think global and act local.*

When a disaster hits a particular location, the affected communities act as the first responders. For smaller events, local response may prove adequate enough and nothing further may be required. There may be situations, however, when effect of a disaster travels way beyond the territorial boundaries, and may even capture the global imagination. We may also have situations in which effects of a global catastrophe travel to several distant locations. In other words, a local event may have global consequences and a global event may have local implications. In both cases, the response to a disaster has to be quick, measured, and effective. Very few of us, however, realize that in some cases, thinking globally in time may prevent events which would have otherwise occurred locally. Similarly, stitch in time at local level may have the potential to avert global crisis.

Let us consider the example of the Indian Ocean tsunami of December 2004 which originated because of an underwater earthquake off the coast of Sumatra in Indonesia. The whole world knows that its devastating effect traveled to as many as 14 countries, each requiring local actions in countries affected. The local actions in all these cases were weaker to the extent that these actions failed to take advantage of global thinking in early warning, rescue, relief, reconstruction, and rehabilitation. Thinking globally before acting locally may have several other benefits as well. In this very case, the earthquake which triggered the tsunami was so strong that it has changed the seismic landscape of the area. This scientific fact, currently under deeper study, may in future influence the global thinking in the science of forecasting and managing future tsunamis in the region.

Like the Indian Ocean tsunami, which fanned out through massive sea waves starting from the epicenter of the earthquake, there are examples of fires which originated from small areas and were fanned by winds to engulf and destroy cities such as London in 1666, Rome in 1764, and San Francisco in 1906. It is because of the consolidated body of such global experiences that it has now become possible to prevent the spread of fires through local action.

Let us consider the importance of thinking globally before acting locally in the context of climate change. Thinking globally, the small island states fear submergence due to rising sea levels because of the climate change. Ordinarily, one might conclude that in such cases nothing much other than construction of dykes and coastal protection can be achieved at the local level. This is not entirely true because every country including Small Island States have the responsibility to reduce carbon emissions.

Similarly, it would not be enough to see the threats due to melting of the glaciers and formation of glacial lakes only in terms of devastation resulting from glacial lake outburst floods and landslides. Melting of glaciers negatively impact on the climate change and therefore on the future of our planet as a whole. Our goal should, therefore, be to evolve an approach wherein we can think globally to take care of bigger issues and act locally to solve our local problems, retaining the holistic perspective in view.

Global experiences are invaluable but these cannot be blindly transplanted to local situations. Even the issues like the selection of technologies for rescue and for reconstruction and rehabilitation will call for informed choices with full appreciation of a plethora of possibilities in the global market and limitation of technology assimilation and utilization at local level in any given case.

Scope of Coverage

The conventional teaching programs on disaster mitigation and management cover both the pre and post-disaster scenarios, Fig. 1.5. *The predisaster agenda* focuses on P's that include preservation, prediction, prevention, and preparedness and E's which stand for environmental improvement, emergency needs assessment, empowerment of communities, and early warning. *The post-disaster agenda* focuses on 4 R's, namely, rescue, relief, reconstruction, and rehabilitation. Since disasters are sure opportunities to build back better and to add to the expanding pool of knowledge, all aspects of them need to be studied to the last detail. The findings of such studies facilitate integration of disaster management with,

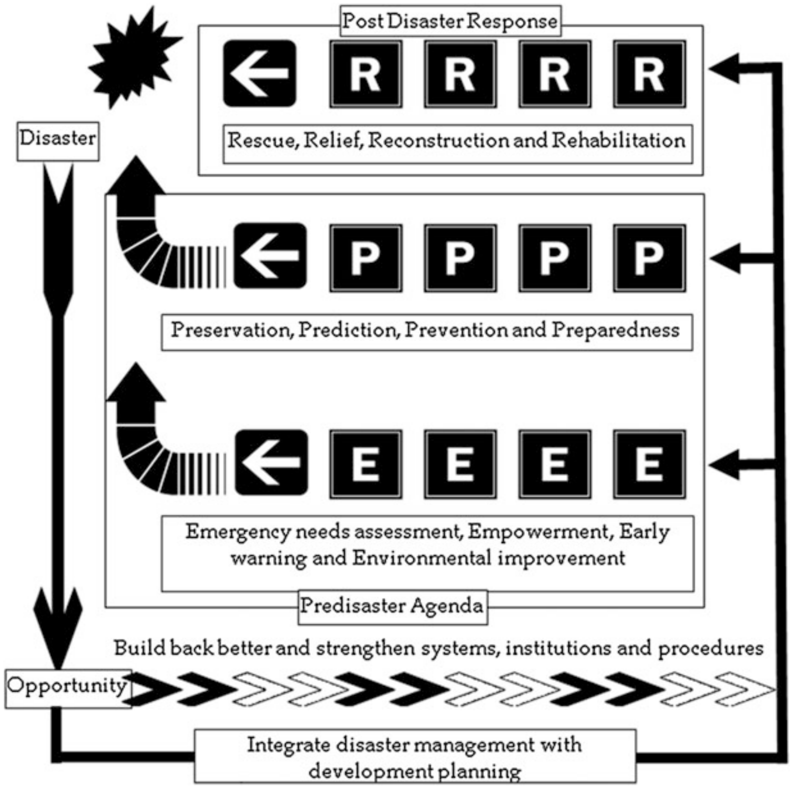


Fig. 1.5 The disaster cycle

developmental planning. The scope of coverage should be holistic so that the disaster education we impart lead to building the cultures of strategic thinking, prevention, and preparedness on the one hand and the culture of quick response to disasters, on the other.

Obligation of Educational Institutions

It is the prime obligation of the knowledge institutions dealing with disaster education to fashion education that prepares citizens who could resolutely face the real life problems in a matured manner. Such institutions should also support governments in ensuring supply of quality educational materials (text books, field, and training kits) as well as high quality teachers. This is because, in a sense,

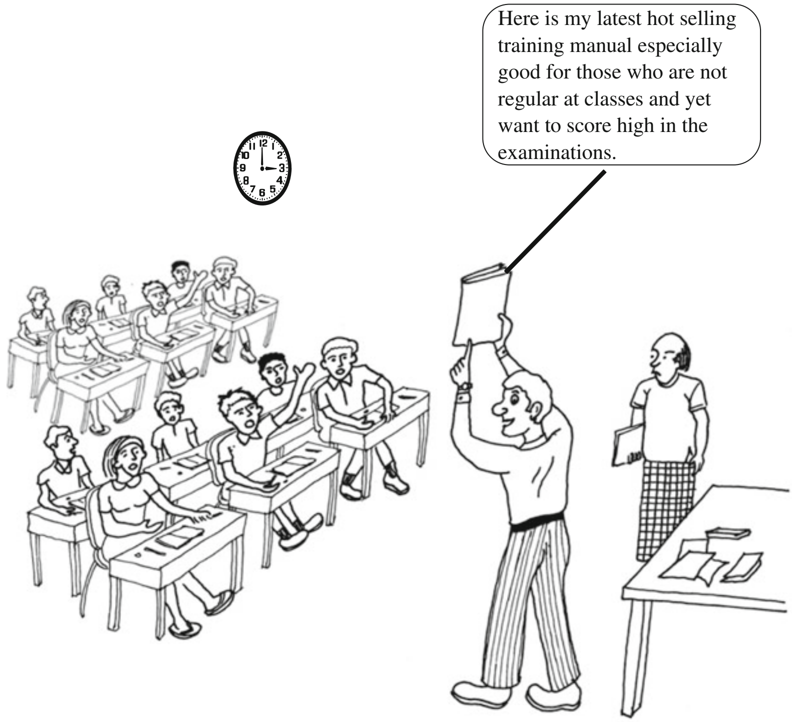


Fig. 1.6 The greatest handicap to the students of Disaster Management is the rarity of good training materials and good instructors

disaster education is only as good as the quality of teachers and teaching aids, Figs. 1.6 and 1.7. Good teachers look upon every disaster as a rare learning opportunity to move the wheels of knowledge, but for the teachers with old mindsets, disasters are no more than repeat of events they think they know all about. They seem to forget that classroom lessons devoid of reality check may mean nothing and it is humanly impossible to create class rooms which can excel the live laboratories created by full-scale disasters.

Fig. 1.7 Sir, I bring to your door step training books on all kinds of disasters. For every book you buy, two comic books and one pack of chocolates will come absolutely free

Teaching, Training, and Retraining

Mark Twain once said that "*training is everything. Peaches were once bitter almonds and cauliflower is nothing but cabbage after college education*" Indeed training is needed at all levels, and for each one of us, regardless of the levels of our previous trainings, Fig. 1.8. It is required to be repeated n-times so as to be able to take the full advantage of the benefits of ever expanding new knowledge and knowledge products, inundating the education space. There are a number of institutions across the globe engaged in the task of training different target groups. The scale and scope of such training should be determined by objective needs assessment and career development, Fig. 1.9. Many hurriedly assembled crash training programs are generally nonserious and such programs should be avoided, Figs. 1.10 and 1.11. What we really need is networking of the training institutions and training and retraining of high quality trainers, Figs. 1.12 and 1.13.

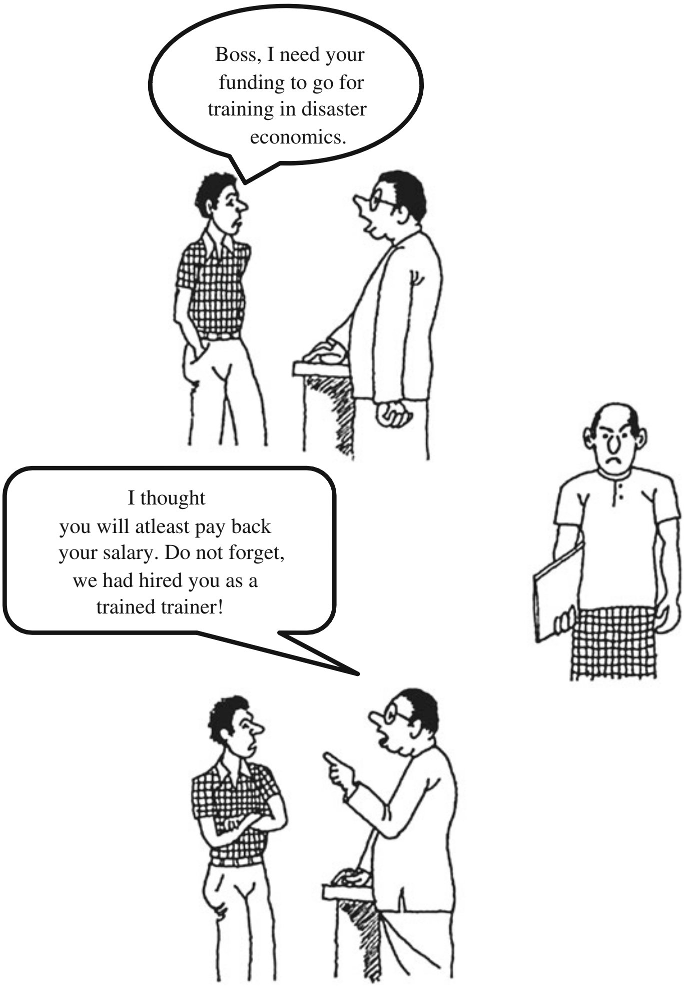


Fig. 1.8 The training is not a onetime affair, it is a lifelong need, "Train everyone lavishly, you can't overspend on training."

Fig. 1.9 Disasters create employment. Proliferation of Disaster Management Institutions and poor quality of education create unemployment

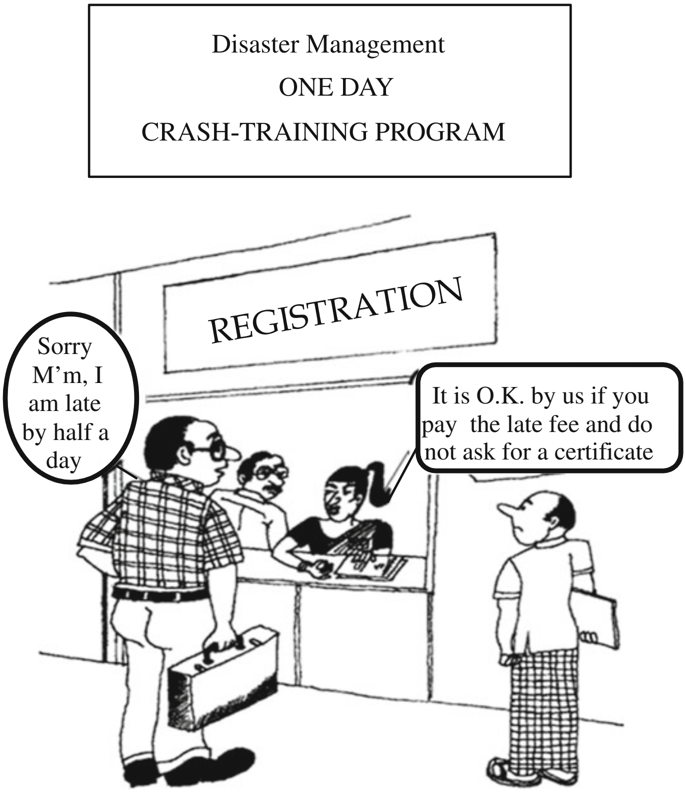


Fig. 1.10 Training and retraining is a serious business both for trainees and training institutes. A ritualistic training is worse than no training and its adverse effect hits generations

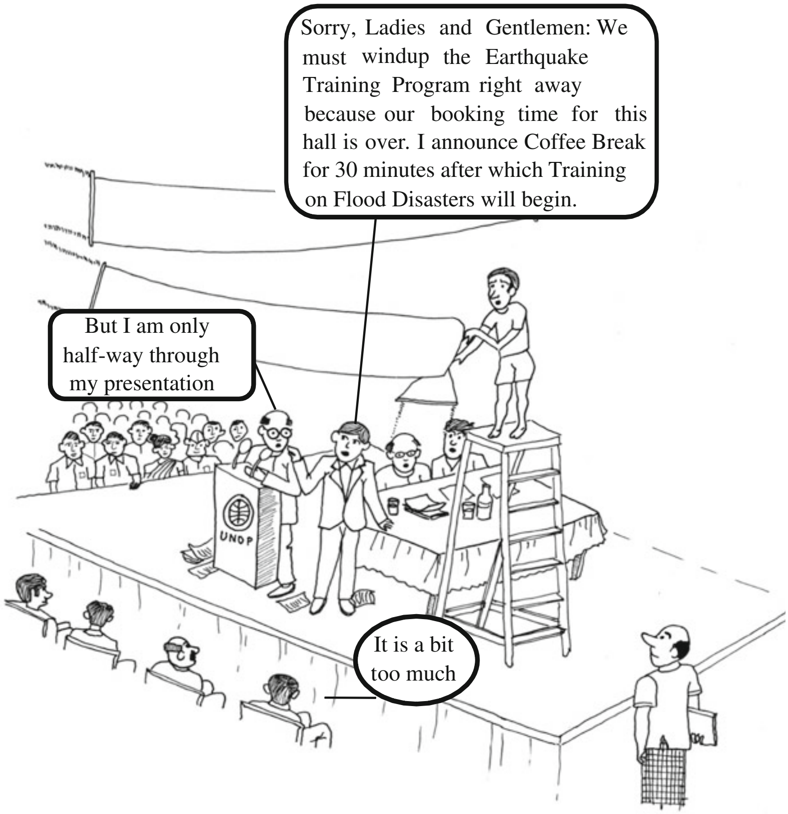
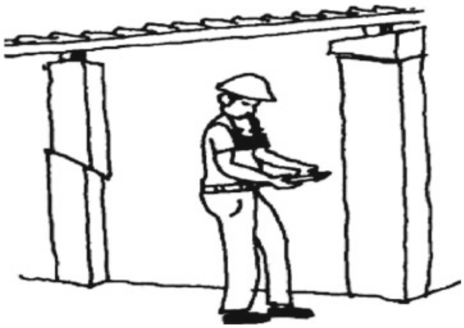


Fig. 1.11 Number and frequency of Training Programs and workshops on disasters are increasing without care for quality and realistic needs assessment. Greater attention is needed on scope, substance, and quality of training

Fig. 1.12 Courage and confidence are the two important traits to be acquired in training but unfortunately these often remain undiscovered in conventional training programs. Training should, among other things, test the grit and commitment of the trainees

Listen carefully. You may otherwise forget, what you hear.

See, read, and write attentively and you may remember what you have learned for sometime



What you do with your hands and experience first hand, you will always remember

Fig. 1.13 Good trainers are great assets. They train young minds in the art of listening, seeing, and working with life-size problems. They give the trainees much more than the bookish knowledge

A good disaster-education should also provide deep insights into drafting of context-specific disaster mitigation and management plans. No disaster mitigation and management plan, even if it were to be drawn in the heaven, would be a success on this Earth unless disaster management is in the hands of trained people. Trained managers approach the worst of the disasters with confidence and composure. Disaster management in untrained hands, on the opposite end, makes even a small crisis look much worse and messier.

The growing culture of meaningless conferences must also come to an end, Fig. 1.14.

Way Forward

We can achieve disaster education of our dreams by aiming squarely at the objectives outlined earlier. In so far as natural hazards are concerned, real education and learning lie outside the class rooms and text books for which we need experienced teachers, Fig. 1.15. A good teacher's influence benefits generations and by the same logic bad teaching hurts more than no teaching. Unfortunately, there is a virtual famine of good teachers when it comes to disasters. Occasionally, the vacuum get filled with 'instant experts' who learn from Internet or text books by the night and teach whatever they can recall, the next morning, Fig. 1.16. Most students want to learn but not the way they are generally taught, Fig. 1.17. Of course they can gain knowledge and understanding of hazards and disasters in a classroom and earn university degrees, but if that class room were itself to be on fire, most of them may have no clue on how to escape the wrath of fire, Fig. 1.18. Many of them may even die of it, or die of the ensuing stampede. This is because the insights necessary to foresee a disaster and the skill and discipline required for averting a stampede lie outside the classroom education. The fire of a tragedy may spare none, but there will always be some remarkable people amidst the burst of cries and weeping, to escape unscathed by putting what they have learned to effective use.

For disaster education to flourish, we need a paradigm shift from knowledge-centric education to an all-inclusive holistic approach. Opening new institutions, universities, and colleges and shoring up the existing systems will only provide some cosmetic relief, Fig. 1.19. What we do require at this juncture are three things. Foremost is the acceptance of the fact that disaster education is critical to universal survival and therefore must figure on our do list. Second, we do need a strong political will across the globe, especially in the corridors of power, to foster, promote, and sustain disaster education. And finally, we need to create pace setter examples and grow a fine breed of quality teachers.

Without making right kind of sounds and adequate investments, we will not achieve much. In fact a wrong start will only mean a deferred call for education reforms, surfacing when the bad education begins to hurt. Since unwinding and rewinding of the ill-conceived disaster education processes are never going to be smooth, it is imperative that we make a healthy rather than a hasty start. Only when we succeed in blending education with joy that the learning will breed excellence and the communities will be safer.

Disaster education is an investment toward shaping our combined future for a safer tomorrow. Naturally, a large part of the investment must necessarily go in prevention and mitigation of disasters. Experience has taught us that post-disaster relief, rehabilitation, and remedial action usually cost a bomb to the exchequer. And even after all that spending, the effectiveness and the impact of what is achieved on the ground is at best cosmetic, and the future of those affected, and their descendants, is at best the very same picture of hope and despair. A government, which usually has no money to provide a blanket for the victim of a cold wave, somehow finds money to pay compensation to support the victim's family after his or her death! Disaster education will give us the wisdom of investing wisely on pre-disaster planning and on reduction of disaster vulnerability thereby reducing funding demand for post-disaster relief, rehabilitation, and reconstruction.

Clearly the current approach to disaster education and management will need a sea change through innovation in our ideas and through our enhanced commitment to the cause. Let us give the right kind of disaster education to the young minds, and for sure they will deliver us a disaster-free-world in return!

Annual Conference on Disasters for Students

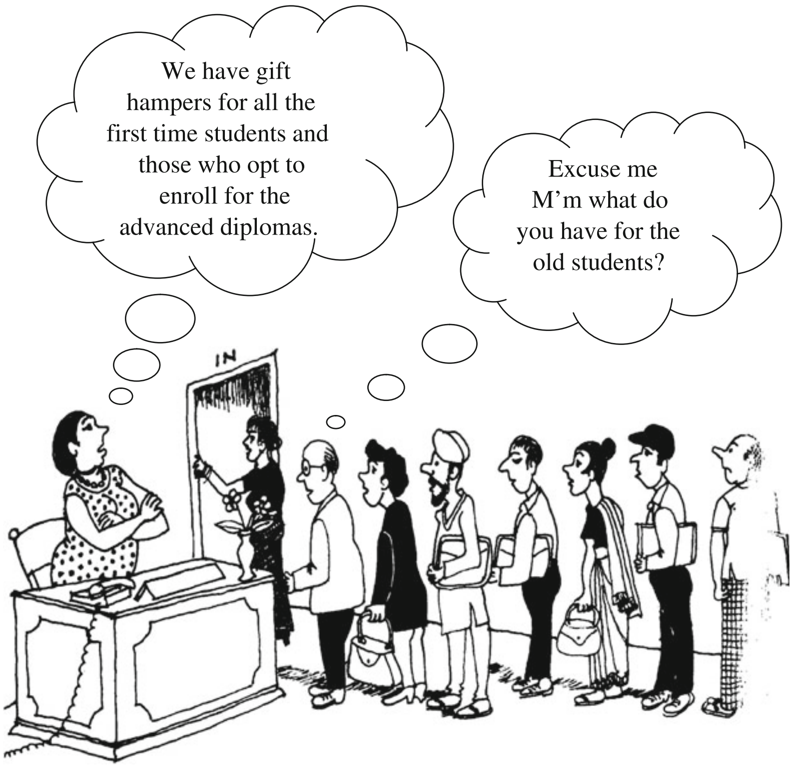


Fig. 1.14 "No grand idea was ever born in a conference but a lot of foolish ideas have died there." Having said that, conferences fashioned to meet the needs of the students may have many advantages. Sharing of diverse ground experiences, exposure to innovative practices, and cross-fertilization of ideas are some of the notable gains

Disaster Risk Reduction Week

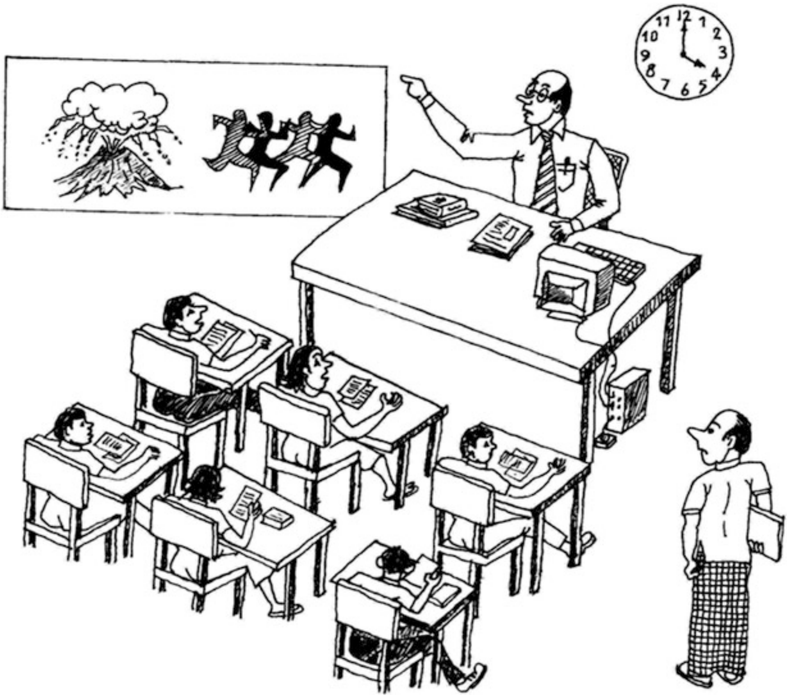


Fig. 1.15 My dear students, frankly speaking, so far, neither I have experienced any disaster myself nor would I like you to face one in your lifetimes. Having said that, teaching is my job and learning is always a good thing for the students!

Fig. 1.16 Good teachers in newly emerging areas like Disaster Management are not created overnight. We need both a short and a long-term plan. According to Dennis Gunton, "Anyone who can be replaced by a machine deserves to be." There is no machine that can replace good teachers, however

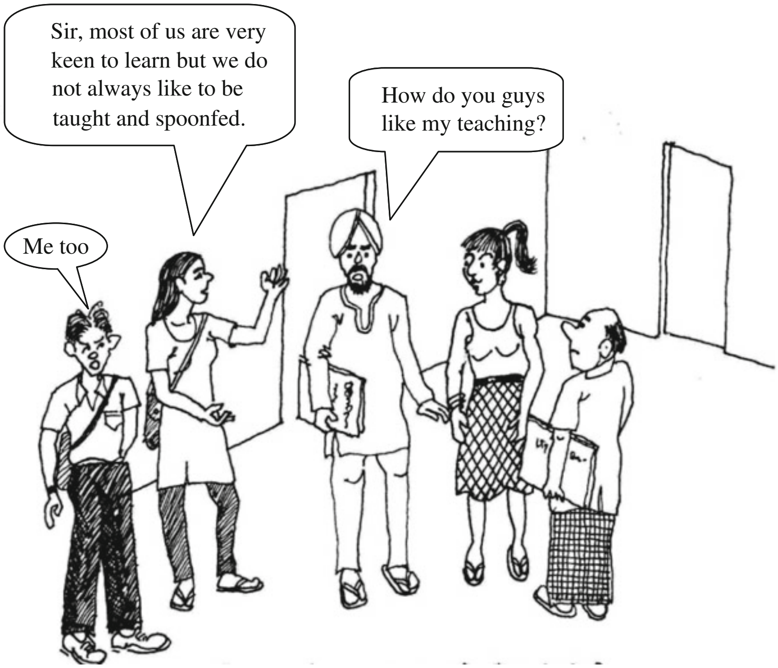


Fig. 1.17 Disasters are in the field but most of the disaster education begins and ends within the four walls of a class room. A good exposure to the real-life problems is what the teachers owe to the students. Education is like continuous supply of oxygen which keeps a candle burning even in the fiercest of a storm

Fig. 1.18 Modern education certainly prepares students to fight the questions they face with war of words which make even the wackier look wise. We need education that provides a down to earth connection with real-life problems

Disaster Free University Annual Convocation

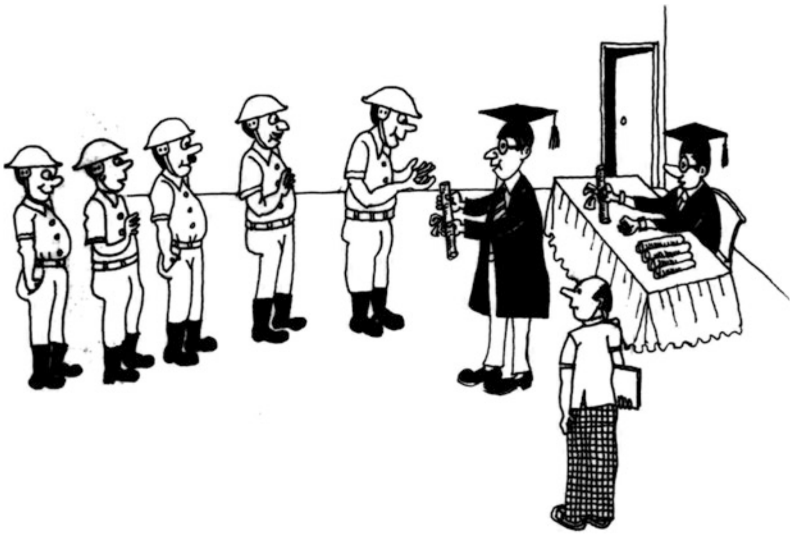
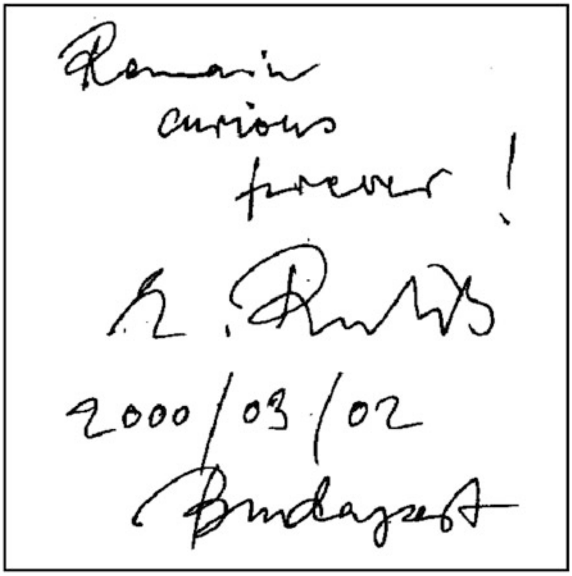


Fig. 1.19 Congratulations for picking the Degree in Disaster Management from this great university. It is your passport to success as long as you are able to hold on to your first job

Break-time Question 2: *What according to you are the five basic virtues you ought to seek on way to disaster education?*

Answer to Break-time Question 2: The five basic virtues we seek are:

(1) **Curiosity to learn about disasters**
Real education, by itself, comes to those who have curiosity to learn. Consider the invention of Rubik's cube which stands out as an unthinkable wonder. When I interviewed Professor R. Rubik, the inventor of Rubik's cube, he attributed the invention to human curiosity and recorded the following on my autograph book:



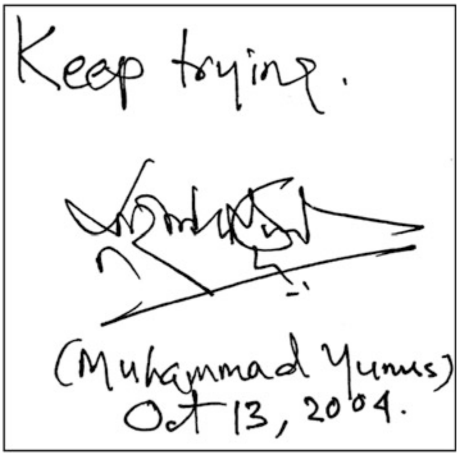
(2) **Freedom from fear of disasters**
Freedom from fear of disasters alone can provide us with the courage to face disasters squarely. The following words of Helen Keller say it all:

> Security is mostly a superstition. It does not exist in nature, nor do the children of men as a whole experience it. Avoiding danger is no safer in the long run than outright exposure. Life is either a daring adventure or nothing.

(3) **Equanimity**
Disasters turn joy into sorrow, pleasure into pain, and success into failure. We need equanimity to enhance our capacity to take life as it comes. Those who are able to conduct themselves with equanimity make a huge difference to whatever they do. In the words of Albert Einstein,"few people are capable of expressing with equanimity opinions which differ from prejudices of their social environment. Most people are even incapable of forming their opinions."

(**4**) **Sense of service**
Disaster education should give us the sensitivity to feel the pain of those in distress and inculcate in us a sense of service beyond self. We should know that we cannot be safe, if our neighbors are not. If we see the beauty and joy in serving others, we can be rest assured of help from others in our own time of distress.

(**5**) **Ambition to succeed despite setbacks and failures**
While dealing with the hydra-headed aspects of natural hazards, setbacks, and failures are certain. For instance, one area of recurring setbacks and failures is prediction of geohazards such as earthquakes, volcanoes, and landslides. Such failures should not dampen our enthusiasm but only redouble our resolve to *keep trying* with an ambition to succeed. This is what Muhammad Yunus, the Nobel Laureate, recorded in my autograph book.



Disaster Terminology

2

Abstract

While speaking of disaster risk reduction, mitigation, and management, use of right terminology is critical to ensuring effective communication between all players. The chapter, while introducing the commonly used terms such as threat, danger, hazard, disaster, crisis, calamity, catastrophe, and cataclysm, throws light on their respective origins and uniqueness. The meaning and importance of the twin terms—rumor and panic, and of the trinity—hazard, vulnerability and vulnerability and risk, are explained. While the boundary between natural and man-made disasters is obscure and disputed, the thin line that divides the success of disaster management from the failure of disaster mismanagement is almost always visible. The point is made through cartoons and illustrations.

Contents

R. K. Bhandari, *Disaster Education and Management*,
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The biggest problem in achieving effective communication between various actors is inappropriate use of terminology, Fig. 2.1. Some of the commonly used terms are discussed below:

Threat

Threat is the state of being exposed to a hazard, harm, injury, or damage. It is also a source of danger. For example, a poisonous cobra is a threat to the man below who is attempting to catch it. A possible snake bite is the danger he faces. This threat gets removed as soon as the cobra gets caught without doing any harm. When the threat gets removed, the danger disappears, Fig. 2.2.

Danger

The term Danger means the state of being face to face with any kind of threat with a possibility of serious loss, injury, or death, Fig. 2.3.

Natural Disasters

The terms Hazard and Disaster are explained in Figs. 2.4 and 2.5. Natural hazards are usually associated with atmospheric, geologic, seismologic, volcanic, and such other natural factors. Earthquakes, tsunamis, landslides, volcanoes, avalanches, floods, hurricanes, and lightning are some of the examples. According to a recent UN World Bank joint publication, disasters have killed nearly 3.3 million people in the last 42 years with variable year-to-year trends, drought has taken toll of more lives than any other disaster and the poor countries have suffered the most.

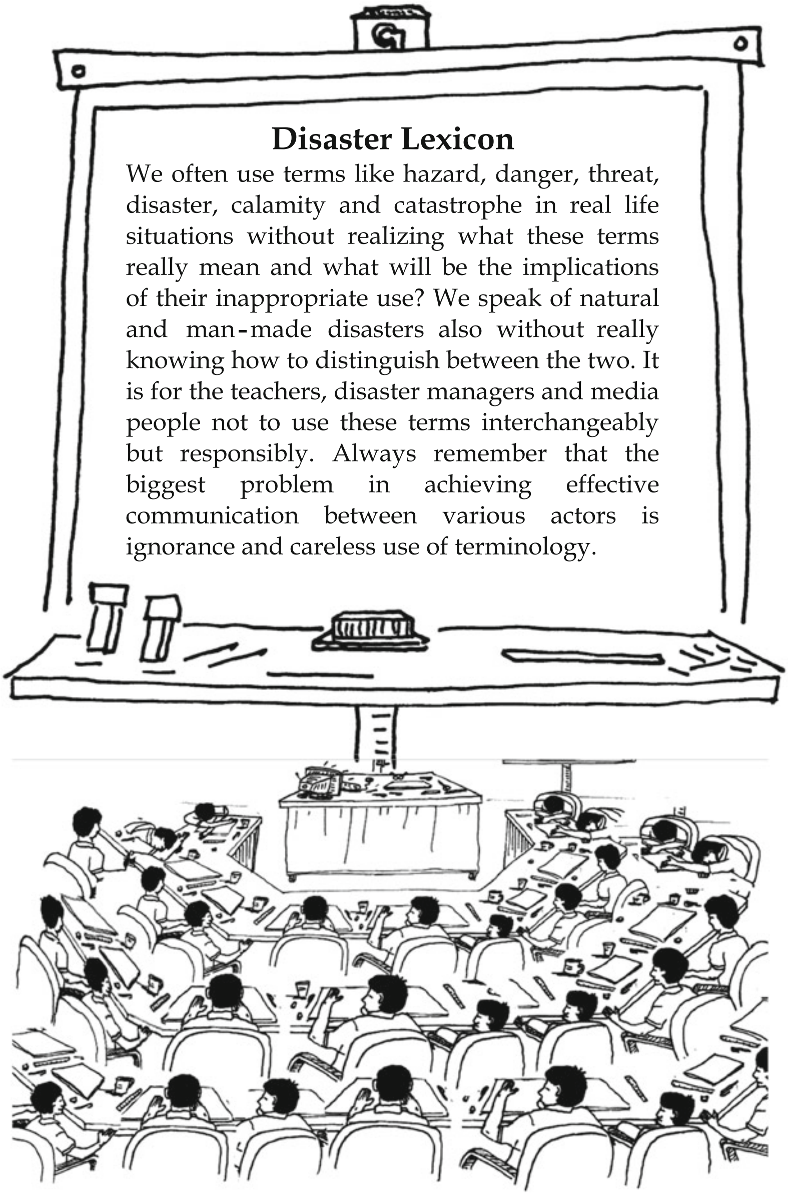


Fig. 2.1 Common terminology is essential not only for effective communication but also for efficient disaster management

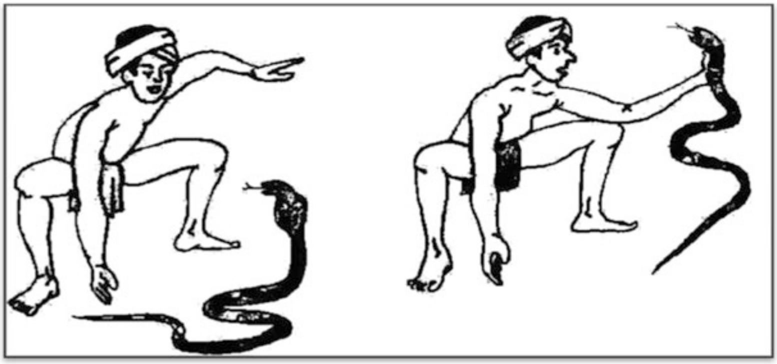


Fig. 2.2 A poisonous snake is a threat

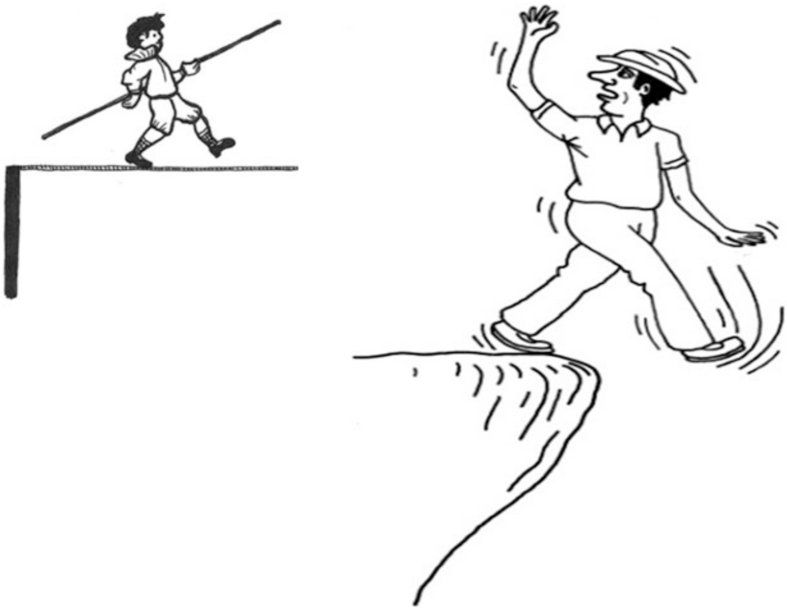


Fig. 2.3 One who fails to watch his or her steps faces the danger of an imminent fall

Man-Made Disasters

Man-made disasters are usually associated with anthropogenic factors, especially the industrial, biological, chemical, nuclear, technological, mining, transportation, and such other causes. Man-made disasters associated with Hiroshima, Bhopal, Chernobyl, the Exxon Valdez, and Fukushima are ugly scars on the otherwise beautiful face of humanity, and the shame of these scars no plastic surgery can conceal. Terrorism constitutes another major threat. To know about the nature and magnitude of the threat, just read the ghastly stories of what happened in New York on 9/11 or in Mumbai on 26/11, Fig. 2.6.

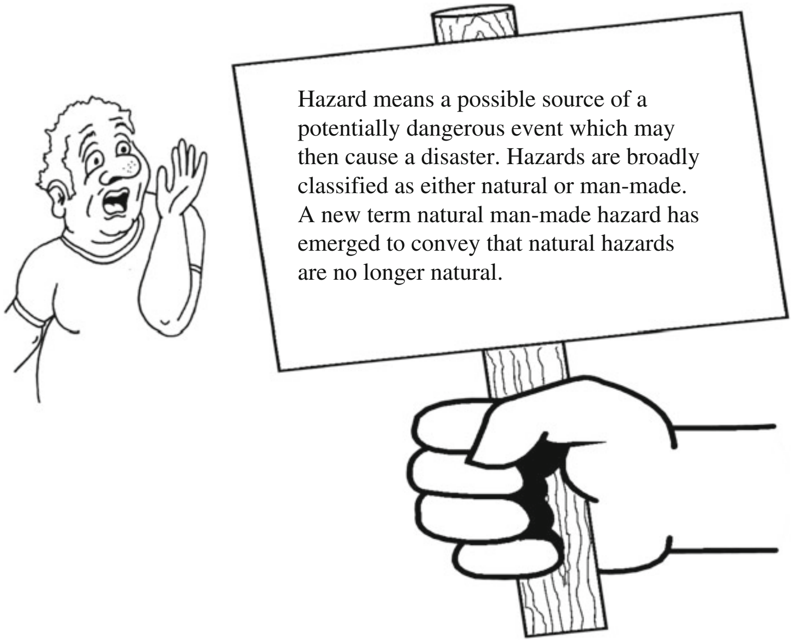


Fig. 2.4 The meaning of term Hazard

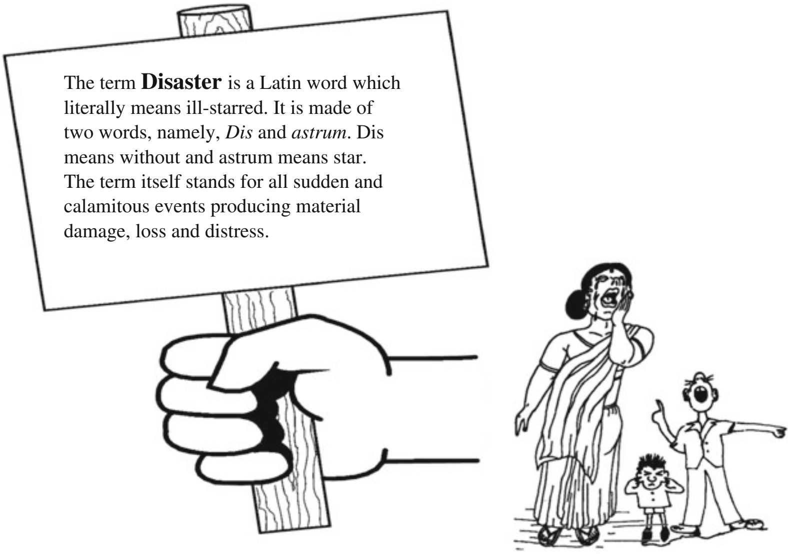


Fig. 2.5 The meaning of term Disaster

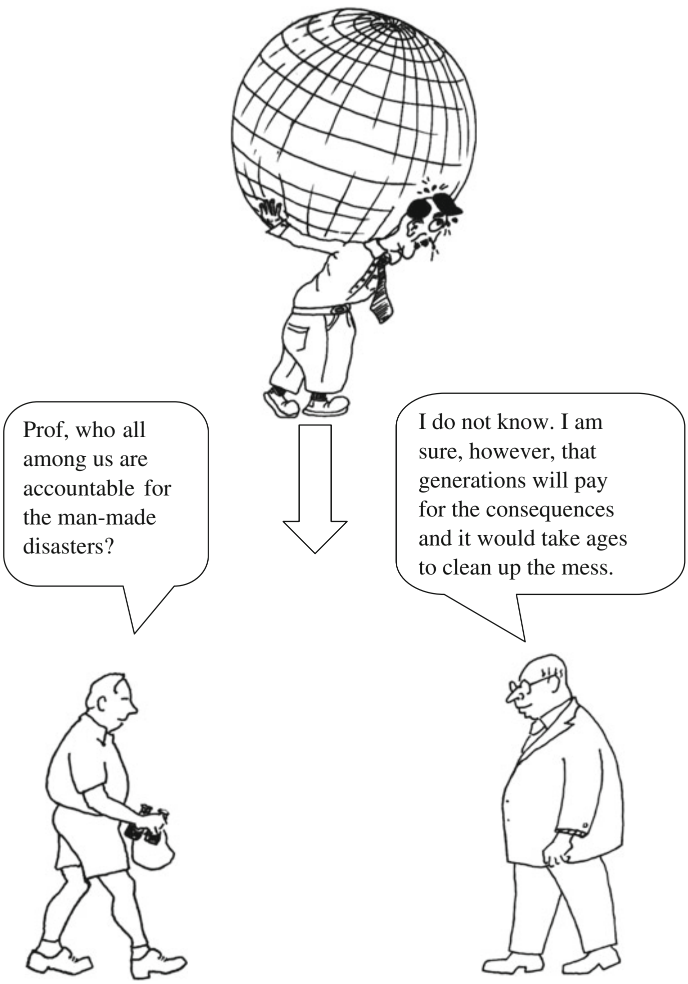


Fig. 2.6 The impact of man-made disasters will hit generations. With the business as usual, we are driving the already alarming situation to the point of no return

Difference Between Natural and Man-Made Disasters

According to Albala Bertrand,[1] "For the sake of contrast, a natural disaster is one induced by a natural event (e.g., earthquake, flood, and volcano), whereas a man-made disaster is one resulting from the breakdown of regular process with a social system (e.g., war, recession, riots, and technological failures). The main difference between them is simply the primary force which unleashes them."

[1] J. M. Albala-Bertrand: In the Political Economy of Large Natural Disasters' with special reference to developing countries. Clarendon Press, Oxford, 1993.

Fig. 2.7 Every disaster offers great opportunities

Crisis

"The word *crisis* is of Greek origin, meaning a point of instant impending change, one-way or another." The Chinese word for crisis is made of the ideograms for *disaster* and *opportunity* (Fig. 2.7).

Calamity

Calamity means an extraordinarily grave event causing misery, misfortune, grievous affliction, adversity, and great loss and leaving behind a trail of lasting distress, emotional outbursts, affliction, and grief. The pain inflicted by a calamity is more from personal or general grief and sorrow, rather than from other causes.

Catastrophe

The term *catastrophe* finds its origin in the Greek word, *Kata streiphen* in which *Kata* means *down*, and *streiphen* means *turning over*. It follows that catastrophe is another name of an irrevocable tragedy which goes beyond disaster or calamity. In terms of catastrophe theory, however, *catastrophes* are more precisely defined as events which affect *systems*.

Cataclysm

Cataclysm is the term used to describe an overwhelming event climaxing in upheaval and destruction of an established system. Unlike the use of word calamity, the term cataclysm is used in the context of general or universal happenings rather than personal happenings.

Adversity is Also an Opportunity

Disasters are being universally hated for they separate us from our near and dear ones. Thousands get killed; tens of thousands are rendered homeless, and development clock is set back by decades. At times, the living feels worse than the dead, Fig. 2.8.

Victims of a disaster respond to it differently. The reasons are many. When face-to-face with crisis, the wise among them care more for what is left than what has been lost. They even accept the pain of the moment as a rare experience and focus all their energies in tiding over the crisis situation. They know that bad times do not remain forever and the event they are going through, no matter how ghastly, will also pass. On the other hand, the weak among them shed tears and their tears prevent them from seeing hope and light under the clouds of gloom and darkness around. Only cool minds, positive thinking, freedom from fear, and forward action can convert an adversity into an opportunity.

Every disaster gives us an opportunity to learn, innovate, and emerge stronger. It offers live laboratories of nature to re-analyze and re-evaluate the previous body of knowledge, raise a fresh set of questions, discard baseless assertions, and add a few more bricks to the edifice of knowledge. Every disaster provides policy makers the heaven sent opportunity to put their policies on the anvil. Professionals charged with the responsibility to manage disasters, likewise, get a good share of their chance to introspect and see by hindsight where they went wrong, why their preparedness plans misfired, and how their strategies let them down so badly? Scientists do get an unexpected load of new problems, and enough food for thought to rewrite their research proposals in search of cost-effective solutions anchored to the ground realities. Since dead tell no tale, those who survive are the most reliable carriers of messages. Let us give them an ear and try to find out what is their story? If the desire to learn is genuine, disasters will always strengthen the weak, and arm the strong.

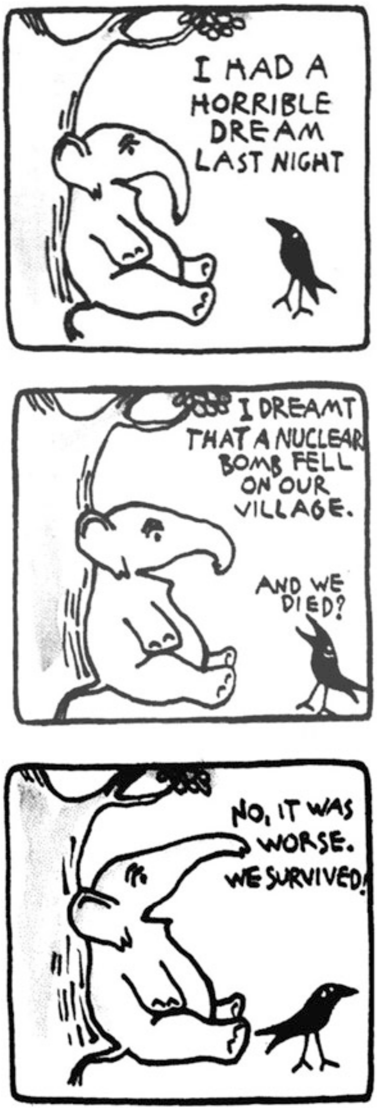


Fig. 2.8 The fate of the survivors of a disaster is worse than the pain of the dead. (*Source Hindustan Times*, 2 August 1998)

Emergency, Rumor, and Panic

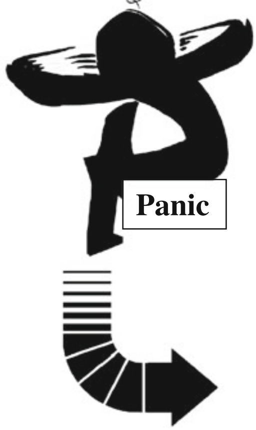
Emergency

The word *emergency* is the hybrid of the words *emerge* and *urgency*. The word *emerge* is the opposite of the word *merge*. An emergency represents a sudden departure from the normal and the familiar. It is opposite of normalcy, and *rumor* and *panic* are its two naughty children.

Rumor (Figs. 2.9–2.11)

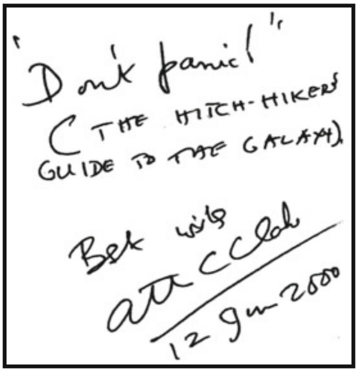
"Rumor, of all evils, is the swiftest. Speed lends her strength, and she gains vigour as she goes; small at first through fear, soon she mounts to heaven, and walks the ground with head hidden in the clouds."

Vergil, AEneid Bk IV, l, 174



Panic

The word *Panic* came from Pan, the Greek God, traced to Greek mythology. Pan, had torso of a human and horns, legs, and beard of a goat. He routinely roamed in the forests and meadows and played on the flute in the daylight. Under the cover of night, he spent his time in the conquest of nymphs and played tricks on the travelers. As the story goes, Pan made strange sounds to terrify people passing through the wilderness of the mountainous terrain, forcing them to run for their lives. The fear which made people run was termed Panic.



Source Direct from the pen of Arthur C. Clarke. *Source* the author's autograph Book.

A Rumor Spreads Like a Wild Fire

(See Fig. 2.9)

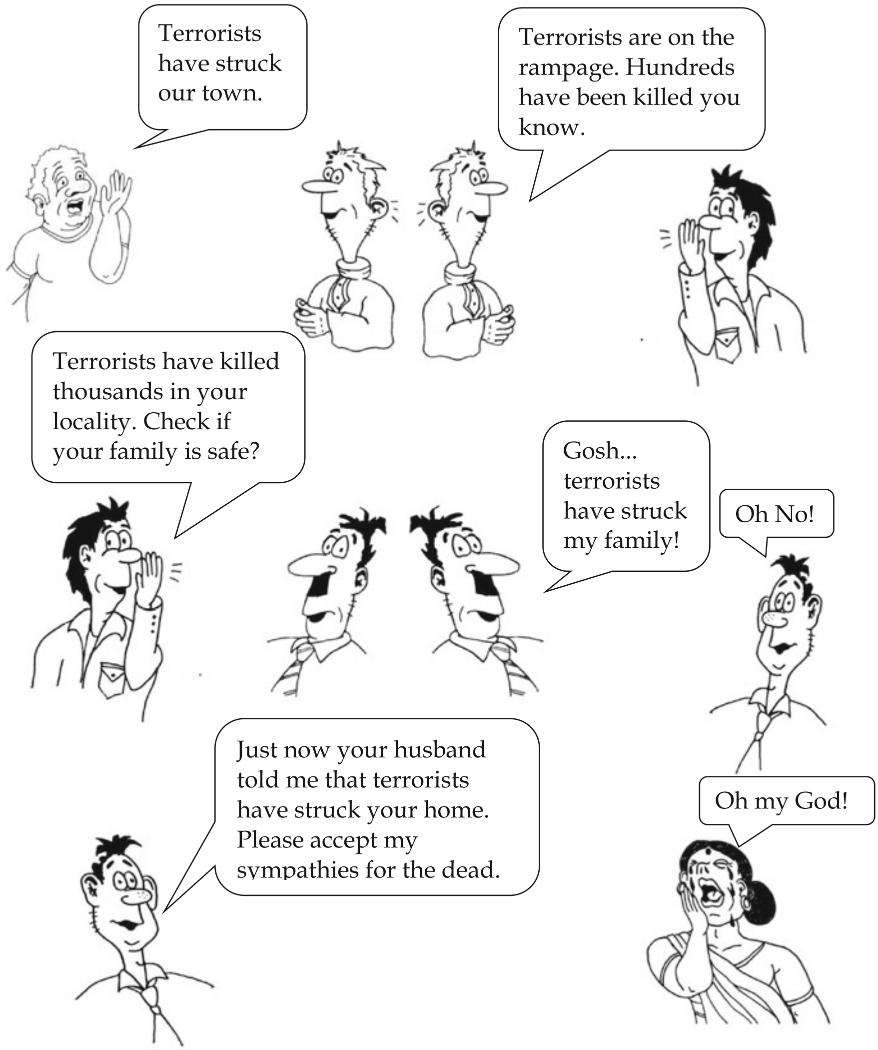


Fig. 2.9 Rumors are a low cost and perhaps the worst weapon to destroy peace and spread falsehood and panic. Spread by word of mouth and via social media, a rumor does exactly the opposite of what is needed to restore peace in the times of crisis

On Facing Crisis and Panic

(See Figs. 2.10 and 2.11).

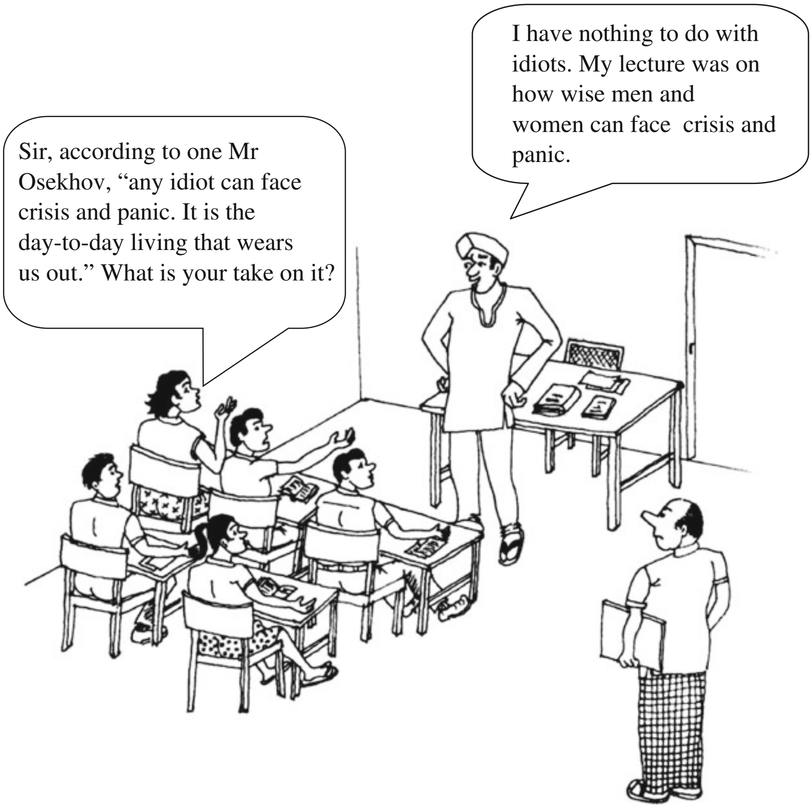


Fig. 2.10 Forget that we can ever face and escape crisis and panic in the times of a disaster, if we are not even able to manage our day-to-day problems in the normal times

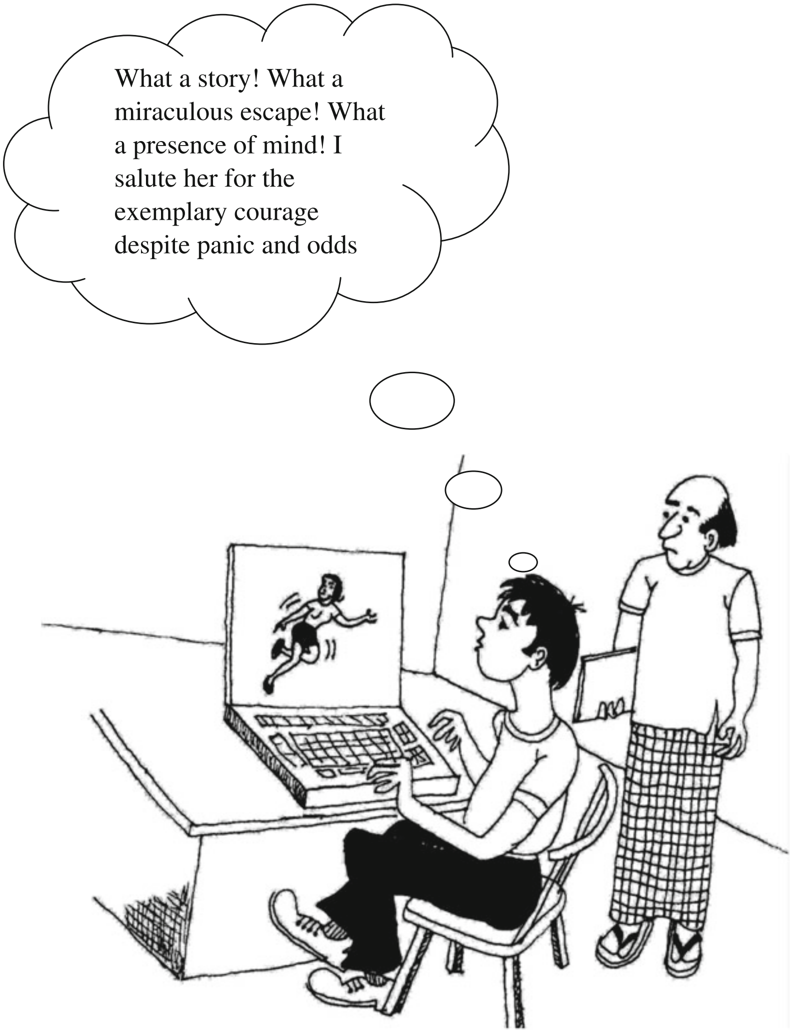


Fig. 2.11 “They fail, and they alone, who had not striven” Quote: Thomas Bailey Aldrich

The Story of Picnic, Panic, and Presence of Mind

Once upon a time, a school party went to a thickly forested area for a picnic. A wild dog suddenly appeared from nowhere and began to chase a couple of students who were strolling in the forest. Naturally, the students felt threatened, because of their direct exposure (vulnerability) to the danger (hazard). The risk was of getting rabies in case of the likely dog bite. The students ran as fast as they could to escape

Fig. 2.12 Alert minds face hazards maturely

the danger. The dog continued the chase. Without getting panic, both the students used their presence of mind and climbed up the nearest tree. Once on the tree, they were now no longer vulnerable and therefore faced no threat, danger, or risk from the dog (Fig. 2.12).

Dog then turned his attention to two other students nearby who had failed to climb the tree because they lacked the survival skill to avert the crisis. Being face, to-face with the wild dog, their vulnerability to dog bite was nearly 100 %. Instead of climbing the tree, they began to cry. Their colleagues on the tree, by then, sent a text message to one of the teachers. Fortunately, the teachers came to their rescue and the dog was chased away.

The moral of this story is that alert people with cool temperament, survival skills, and presence of mind can escape danger. We need to improve our skills like ability to climb trees, swim rivers, extinguish fire, and remaining cool in the times of adversity.

Hazard, Vulnerability, and Risk

Hazard: The term *Hazard* means a possible source of a potentially dangerous event which may cause a disaster. It depends on the probability of occurrence of an event, its location, and the strike time. Hazards could be natural such as volcanoes, earthquakes, and tsunamis; technological such as nuclear and chemical plant accidents; or human induced such as terrorism and bombing. Hazards become bigger when they cascade or overlap.

Vulnerability: The term *Vulnerability* refers to the level of susceptibility or degree of exposure to hazard risks. Natural hazards such as earthquakes and volcanoes cannot be reduced but these hazards will not affect us adversely if we take steps to reduce our vulnerability (exposure) to such hazards. For instance, vulnerability of people living in unsafe buildings will be close to 100 % because earthquakes are known to kill people by collapse of buildings. By making buildings earthquake safe, the vulnerability can be reduced from 100 % to virtually 0 %.

It is not always true that higher hazard levels endup with disasters. Hazards turn disasters only when our *vulnerability* level is high and our degree of preparedness is low. A very high technical expertise is needed to map vulnerability because of great uncertainties involved in the process. The mapping of vulnerability becomes even more difficult when we face clustering of hazards striking at different locations, timings and durations.

Risk: The term *Risk* conveys the consequence of a hazard usually specified in terms of economic worth of loss. For determining *risk* involved in a disaster, we need to know the level of *hazard*, the elements at risk, and the associated *vulnerability*. When hazard is H and vulnerability is V, the risk involved will be the product of the two.

Where there is no *hazard*, we fear no disaster or risk. By mapping distribution of a hazard, we obtain the zones of varying degrees of the hazard, from exceptionally low levels to exceptionally high levels. Higher the hazard level more is the likelihood of risk for a given vulnerability. Higher the risk, the higher will be the losses. For expressing levels of risk, we attempt to quantify expected number of lives lost, people injured, property damaged, infrastructure disabled, development work hampered, environment destroyed, and so on.

Types of Vulnerability

Ordinarily, wherever there is a hazard, there will be some risk. We can compute the risk due to a given hazard by quantifying vulnerability. Quantification of vulnerability is a highly specialized task often left to the intuition of the individuals and mapping by specialists. It is, however, important for each one of us to know that our vulnerability (exposure) to a hazard can appear in different uniforms. Here are some examples:

Physical Vulnerability

(Example: People living in unsafe buildings in earthquake-prone areas are physically vulnerable).

Economic Vulnerability

(Example: People without financial and material resources are economically handicapped and therefore more vulnerable than the rich).

Social Vulnerability

(Example: People without social connectivity and support are socially vulnerable).

Ecological Vulnerability

(Example: Communities and people unprotected from the on-going ecological degradation are ecologically vulnerable).

Organizational Vulnerability

(Example: Communities without capacity and organizational support are organizationally vulnerable).

Communicational Vulnerability

(Example: Communities without access to information and telecommunication facilities suffer from communicational vulnerability).

Attitudinal Vulnerability

(Example: Communities without behavioral training, education, and awareness suffer from attitudinal vulnerability).

Political Vulnerability

(Example: Locations without political patronage suffers from political vulnerability).

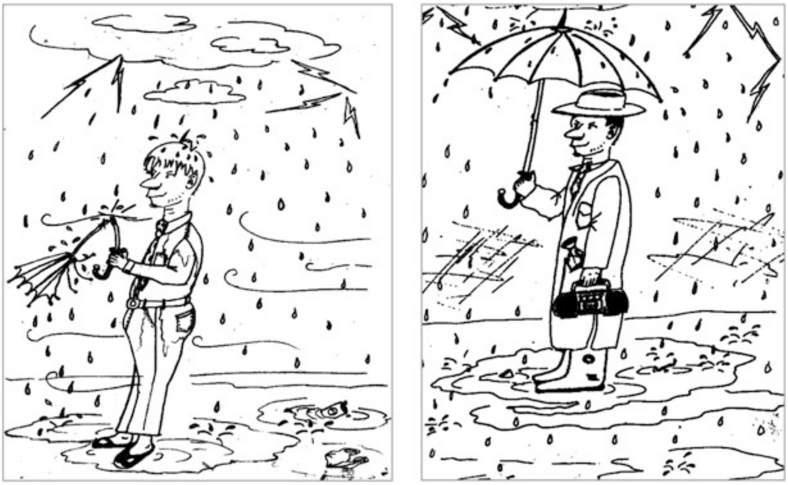


Fig. 2.13 Preparedness for safety should become part of our habit and way of life. It is pointless to invest in preparedness and throw away the benefits when needed the most. The virtue of preparedness is as much a matter of capacity building as it is of mindsets. In the above two pictures, contrasting attitudes are shown in response to a forecast of thunderstorms and lightning

Preparedness

Preparedness implies readiness to face an imminent threat of disaster 24 × 7 in every possible way. Best proof of preparedness is disasters foreseen and averted (Fig. 2.13). Prepared communities rehearse well-structured disaster management plans and improve upon their abilities in the areas of team effort, skill development, forecasting, early warning, and timely evacuation. Where disasters are unavoidable, it is through disaster preparedness only that lives are saved and losses are reduced by timely rescue, prompt relief, and coordinated management action.

Disaster Mitigation and Management

Disaster Mitigation

Disaster mitigation encompasses the whole range of initiatives and actions aimed at minimizing the adverse impact of a disaster before it could occur. In scope, it goes beyond disaster preparedness inasmuch as it includes the entire sweep of activities, both structural and nonstructural. Structural mitigation involves measures such as retrofitting of buildings and infrastructure. Nonstructural mitigation involves measures such as disaster education, disaster policy planning, forecasting, and early warning.

The scope of disaster mitigation is not limited to mere saving of lives and property. It also includes reducing the negative impact of hazards on economic development, biodiversity, and social institutions.

Disaster Management

Disaster management stands for the whole range of initiatives and actions including policy formulation, strategic planning, administrative, financial, and legal interventions and decision making with particular reference to the entire disaster cycle. The term is sometimes used to refer to emergency management with scope limited to rescue, relief, and rehabilitation in the immediate aftermath of a disaster.

Disaster Mismanagement

When a hazard is allowed to turn into a disaster, and a disaster is allowed to turn into a bigger disaster, because of the lack to planning, absence of preparedness, and delayed response, we get what may be called disaster mismanagement. Good plans are ruined by little minds, poor planning, gross mismanagement, bureaucratic delays, and lack of accountability. The ensuing blame game makes matters worse.

Disasters bring chaos and we cannot afford to add more to that chaos. Imagine if the victims were to die outside a hospital because of a traffic jam and ensuing chaos as seen in the figure above (Fig. 2.14).

There are numerous examples of disaster mismanagement, especially in the resource-starved developing countries. We also have some such examples of disaster mismanagement from the affluent countries like America. Let us take the example of Hurricane Katrina which struck New Orleans on 29 August 2011. The forecast was accurate and timely and yet the damage was heavy and widespread. Two days prior to the devastating event, the hurricane was known to be a category 4 storm. The city levee was known to be vulnerable by overtopping and flooding. The forecast of severe flooding was also known hours in advance of the landfall. The estimate of anticipated loss, projected at $10–14 billion, was highly disturbing. Although by the 30 August, New Orleans stood devastated by flooding, it was rather unusual for the US government to ignore the tragedy in the making. When the Hurricane actually struck, the American President was on a vacation in Texas and later he went to attend a commemoration ceremony at Coronado in California rather than attending to the hurricane. It was not until 31 August that he flew over to get a bird's eye-view of the devastation. His Secretary of State Condoleezza

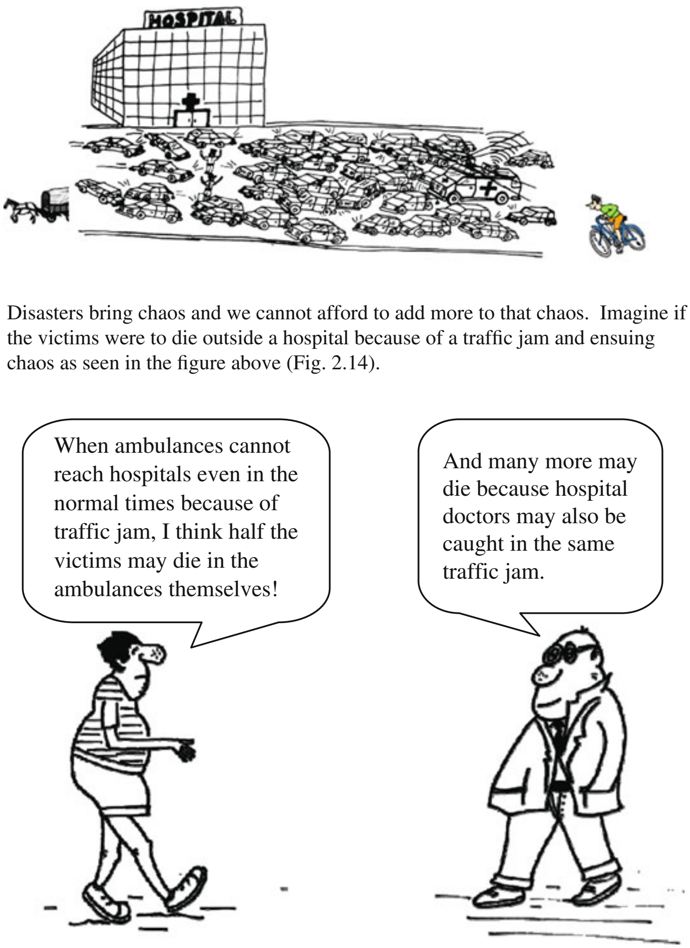


Fig. 2.14 Good disaster management saves lives. Disaster mismanagement leads to blame game. James H. Boren's three point "Guidelines for bureaucrats (1) when in-charge, ponder; (2) when in trouble, delegate; and (3) when in doubt, mumble" given by James H. Boren says it all

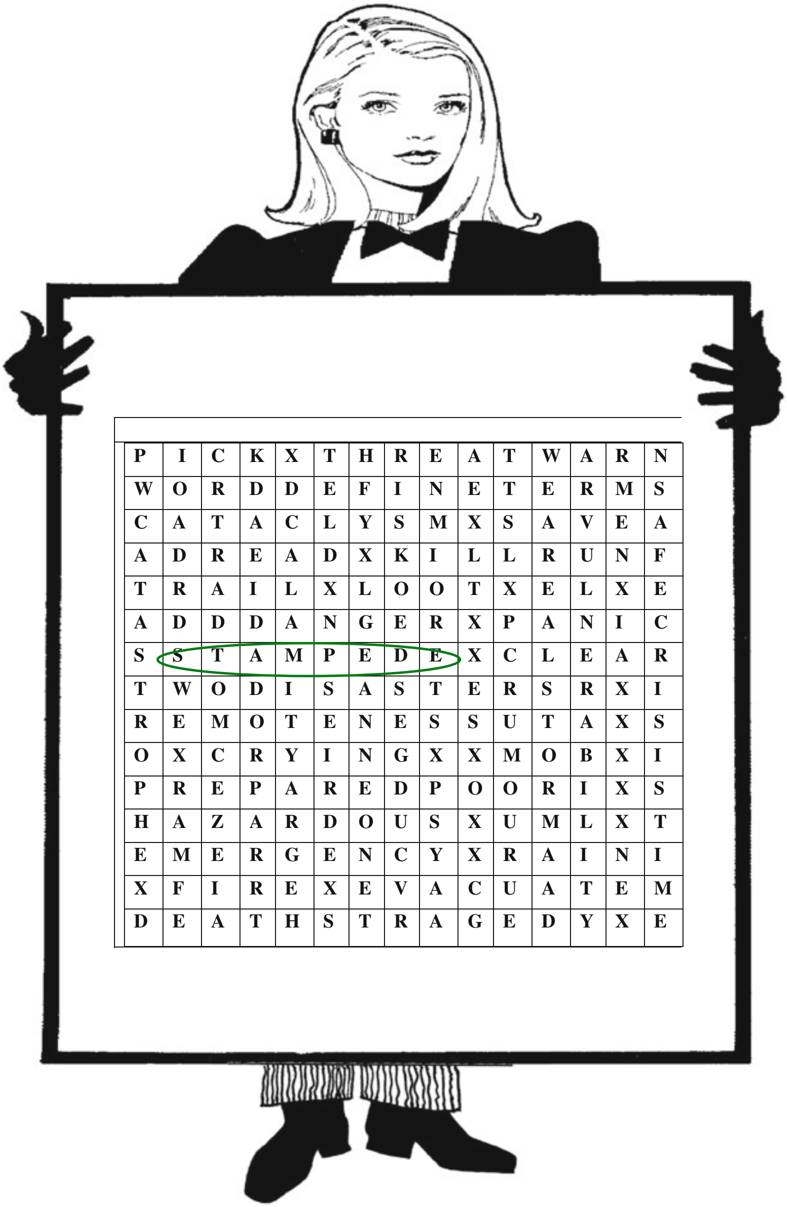
Rice made a candid confession of this lapse in her 2011 auto-biography *No Higher Honor-Memoirs of My Years in Washington.* "She did not think much about the dire warnings of an approaching hurricane called Katrina. She was seen at Broadway play, spamalot and at Ferragamo buying shoes!"

The same US government, however, provided an exemplary display of efficiency in disaster management when hurricane Sandy struck the city of New York in November 2012. The humor in Figs. 2.15 and 2.16 carries profound messages for us all. Let us figure them out and benefit.

Fig. 2.15 In many remote areas where life is a daily struggle for food, water, and clothing, natural calamities are perceived as occasions during which villagers are able to attract the attention of the government and receive material and financial support in gratis

Fig. 2.16 Every disaster screams for humor

Break-time question 3: Recognize all terms connected with hazards and disasters hidden in the box overleaf.



P	I	C	K	X	T	H	R	E	A	T	W	A	R	N
W	O	R	D	D	E	F	I	N	E	T	E	R	M	S
C	A	T	A	C	L	Y	S	M	X	S	A	V	E	A
A	D	R	E	A	D	X	K	I	L	L	R	U	N	F
T	R	A	I	L	X	L	O	O	T	X	E	L	X	E
A	D	D	D	A	N	G	E	R	X	P	A	N	I	C
S	S	T	A	M	P	E	D	E	X	C	L	E	A	R
T	W	O	D	I	S	A	S	T	E	R	S	R	X	I
R	E	M	O	T	E	N	E	S	S	U	T	A	X	S
O	X	C	R	Y	I	N	G	X	X	M	O	B	X	I
P	R	E	P	A	R	E	D	P	O	O	R	I	X	S
H	A	Z	A	R	D	O	U	S	X	U	M	L	X	T
E	M	E	R	G	E	N	C	Y	X	R	A	I	N	I
X	F	I	R	E	X	E	V	A	C	U	A	T	E	M
D	E	A	T	H	S	T	R	A	G	E	D	Y	X	E

Break-time question 3: All terms connected with hazards and disasters in the box are to be spotted out, STAMPEDE, for example.

List of Terms

Count	Term
1	Anger
2	Cataclysm
3	Catastrophe
4	Cry
5	Crisis
6	Clear
7	Disaster
8	Danger
9	Death
10	Dread
11	Evacuate
12	Emergency
13	Fire
14	Hazardous
15	Loot
16	Mob
17	Panic
18	Prepared
19	Run
20	Rumor
21	Rain
22	Remoteness
23	Safe
24	Save
25	Storm
26	Stampede
27	Threat
28	Tragedy
29	Vulnerability
30	Warn

The World of Hazards and Disasters 3

Abstract

The world of hazards and disasters is enormous in its expanse, bewildering in its variety, spectacular in its appearance, masterly in its teachings, and overwhelming in its consequences. The chapter takes the readers on to a conducted tour of a biblical array of hazards and disasters like volcanoes, earthquakes, tsunamis, landslides, lightning, thunderstorms, tornadoes, blizzards, cyclones, floods, famines, and fires. Kaleidoscopic in range, rich in substance, entrancing in style, simple and lucid in presentation, and profound in message, the chapter aims to make every date with disasters a learning opportunity and every lesson from disasters a saving grace.

Contents

R. K. Bhandari, *Disaster Education and Management*,
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Volcanoes

Origin of the Term Volcano

The term *volcano* is traced to *Vulcan*, the blacksmith of the ancient Roman God of Fire and Metal Works. As the story goes, Vulcan had his factory located deep inside a mountain in the Island of Vulcano. The island itself was located in the Tyrrhenian Sea north of Sicily, near Stromboli. Violent volcanic eruptions were regarded as the sign of Vulcan's anger. Violent hammer blows by angry Vulcan at work, created sparks, and these very sparks were believed to surface as volcanic eruptions.

Many legends and myths surround volcanoes from the time immemorial. The Hawaiian mythological literature attributes volcanoes to the anger of their goddess named Pele. The view of a volcano as perceived from the sky and its main features are shown in Figs. 3.1 and 3.2.

Evolution of Volcanoes

Geologically speaking, the volcanic processes are as old as the history of the mother-Earth itself and each time a volcano erupts, it reminds us that mother-Earth continues to be restless and perpetually in the state of dynamic equilibrium. Simply speaking, whenever the equilibrium gets disturbed along the volcanic belt, volcanoes erupt to release the energy serving as safety valves to restore the balance.

The seat of a volcano is generally deep inside the surface of the Earth, in the reservoir of magma. Ordinarily, at depths of about 100 km, the magma is heavier than the surrounding rocks.

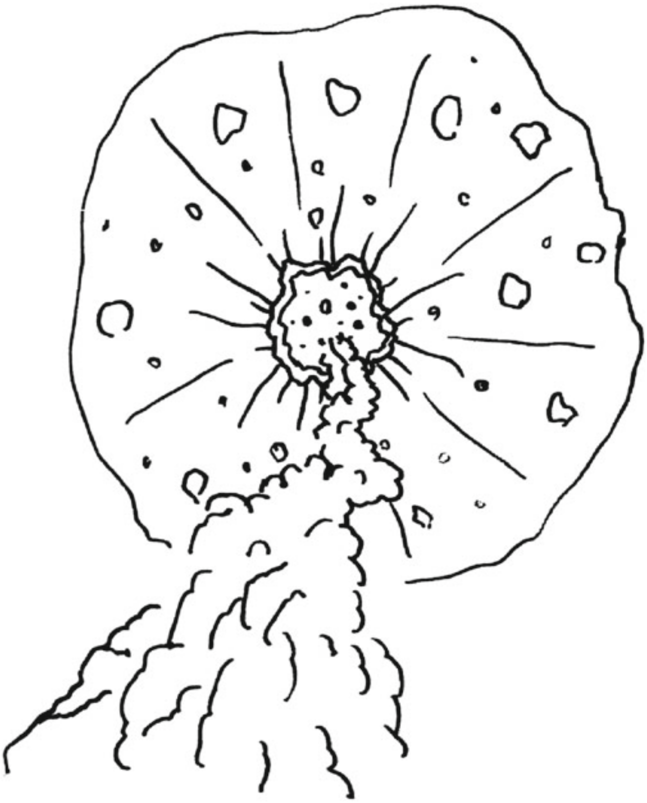
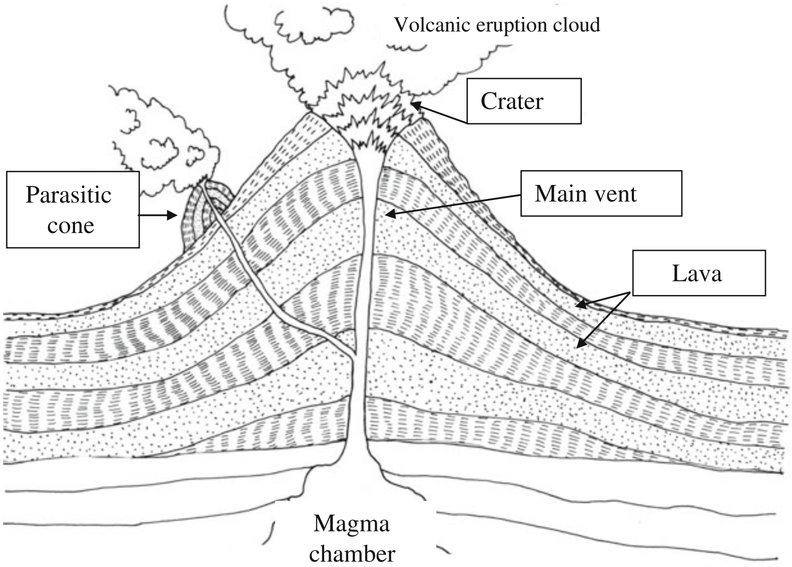


Fig. 3.1 View of a volcano from the sky

Magma moves up either by finding its way through the existing fractures and passages or by creating new ruptures in the overlying rock masses. At deeper depths, because of the high confining (lateral) pressures, gases in magma are generally in the dissolved form. When magma rushes up because of the pressure difference, some of the gases dissolved in it get released. In the process, magma becomes lighter and less viscous. It then acquires added mobility to flow upwards to the higher elevations. As the confining pressure on the magma decreases at lesser depths, its volume increases. The increase in volume in turn leads to fracturing of the associated overlying rocks and consequent opening of new fractures. With the released energy and heat and increased mobility, magma may travel dozens of kilometers eventually erupting as a volcano or feeding into an existing volcano.



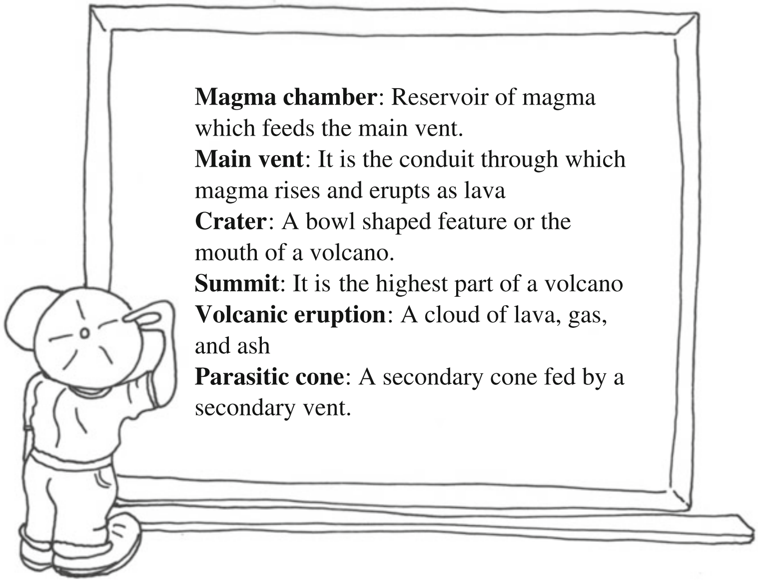


Fig. 3.2 Main features of a volcano

Fury of Volcanoes

Volcanoes are much feared and most dangerous when active. They can poison the atmosphere, blow mountain tops, spit rivers of lava, wipe out cities, plunge skies into cover of darkness for several days, and even change the weather pattern because of the awesome energy levels, lethal and surging erupting gases, and heat blasts.

Volcanoes are also known to trigger rapid motion landslides such as pyroclastic flows, lahars, mudflows, lava flows, and ash flows. Lava flows may show extremes of speeds; from as slow as 1 km/h to as high as 70 km/h. Pyroclastic flows may acquire speeds close to 160 km/h and are composed of a mixture of hot gases and rock fragments at temperatures of about 600 °C. Lahars, as the volcanic flows are called in Indonesia, are known to acquire very high speeds because of the higher mobility of the moving mass due to water-saturated debris.

The good news is that *not* all volcanoes are violently explosive. We also do have volcanoes which are quietly effusive and tourist friendly.

Horrors of Volcanic Gases

The horrors of volcanoes are generally attributed to the horrors of rapid flows and most dangerous of volcanic gases such as sulfur dioxide, carbon dioxide, hydrogen sulfide, and hydrogen fluoride. Sulfur dioxide is highly poisonous, toxic, and corrosive. Carbon dioxide is highly suffocating. Hydrogen sulfide stinks, pollutes, and creates acid rain and haze. Hydrogen fluoride is known to poison the plant life.

Places to Look for Volcanoes

Most volcanoes are in the Pacific Ocean, forming the "Pacific Ring of Fire," Fig. 3.3. Many occur in the island arcs, like the Aleutian Islands extending from Alaska to Asia. There are volcanoes in Japan, Indonesia, and the Philippines.

Volcanic activity is not so prominent in the Atlantic Ocean where it occurs mostly at mid-oceanic ridges, especially in the West Indies, Iceland, and East Africa.

Types of Volcanoes

Shield Volcanoes

Shield volcanoes are dome-shaped volcanoes formed by consecutive deposits of lava spread around their central vents. Upon volcanic eruption, lava travels to great distances because of its high fluidity and develops gently sloping flanks. Mauna Loa in Hawaii is the best-known example of a shield volcano rising 4,207 m above the sea level.

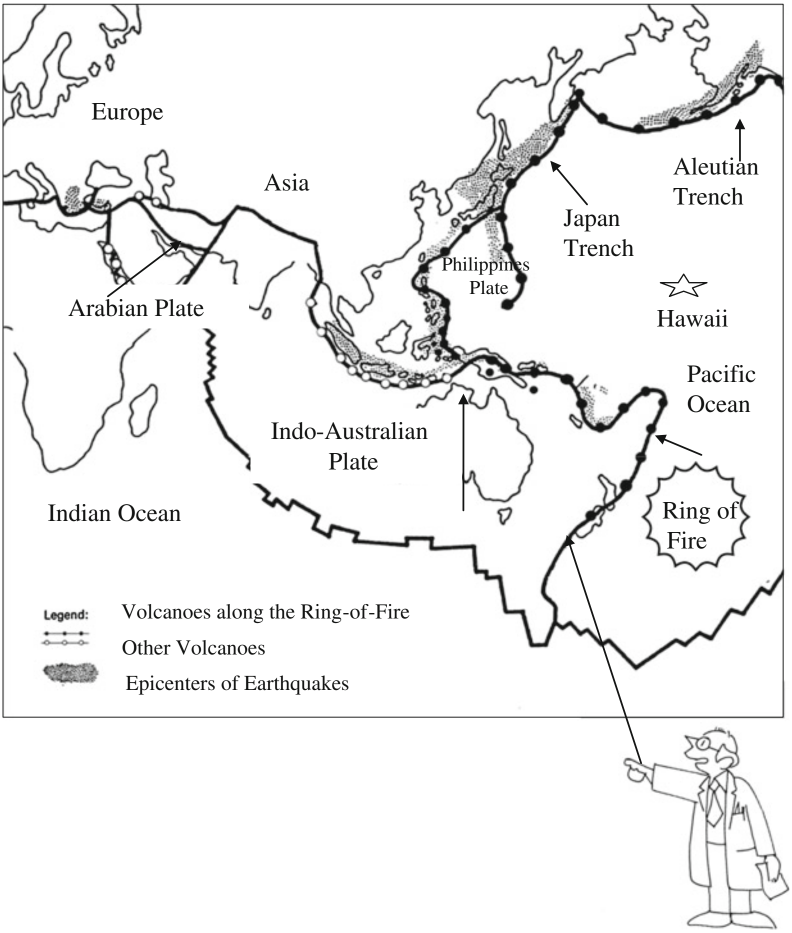


Fig. 3.3 You are face-to-face with the ring-of-fire but at a very safe distance

Strato Volcano

SStrato volcano, unlike the shield volcanoes, is steep-sided, symmetric, and is among the most beautiful volcanoes on the surface of the Earth. Made of layers of lava, ash, and cinders, such volcanoes may reach heights of about 2,400 m. Among the most famous strato volcanoes are Mt. Fujiyama in Japan, Mt. St. Helens in the USA, and Mt. Vesuvius in Italy.

Lava Domes

A lava dome is the name given to a composite volcano. It forms either within the crater of a volcano when lava piles up and solidifies around the vent or on the flanks of a stratovolcano. Mount Pelee in Martinique of West Indies is an example of lava dome volcano.

Cinder Cones

Cinder cones are formed because of explosive eruptions which, inter alia, result in accumulations of volcanic debris, pumice, and ash. They are seldom more than about 300 m in height and are characterized by steep slopes and a crater on the top.

Moods and Tantrums of Volcanoes

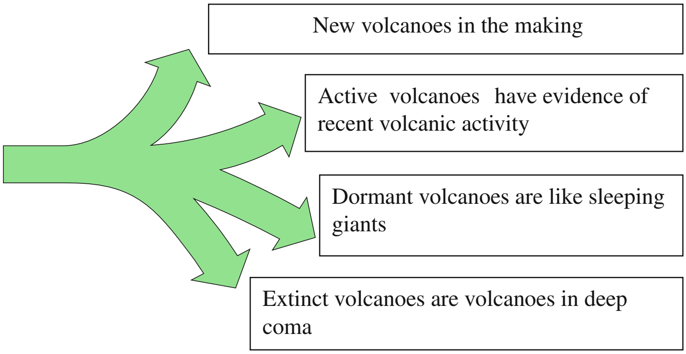
Volcanoes, quiet for centuries, are known to erupt violently. Likewise, the volcanoes which were violent in the past have become quiet today.

Volcanoes of the mid-Atlantic and East African rift and Mid-Oceanic upwelling are relatively quiet but those of the subduction zones around ocean margins are most violent and dangerous.

Hawaii-type volcanoes are known to erupt without violence. This is because the trapped gases in magma normally responsible for violence by bursting are of low order in such volcanoes. Relative absence of trapped gases is due to the low-dissolved water content of the basaltic magma. In contrast, in the Pinian type volcanoes, the dissolved water content of Rhyolite magma is high and therefore it is rich in trapped gases. The violence of eruption in this case is therefore because of gases trapped in the magma.

It is extraordinary that well-formed, symmetrical, steep-sided, tall, and esthetically the most beautiful volcanoes are also the most dangerous. They emit lava of high viscosity and cause short thick flows. In contrast, low-viscosity lava flows travel long distances.

Volcanic Activity



There are about 1,550 known volcanoes of which 500 fall in the active category. Of these, nearly 60 erupt every year. Is there any way to make an active volcano extinct? Let us listen to the answer given by a Professor in the lighter vein, Fig. 3.4.

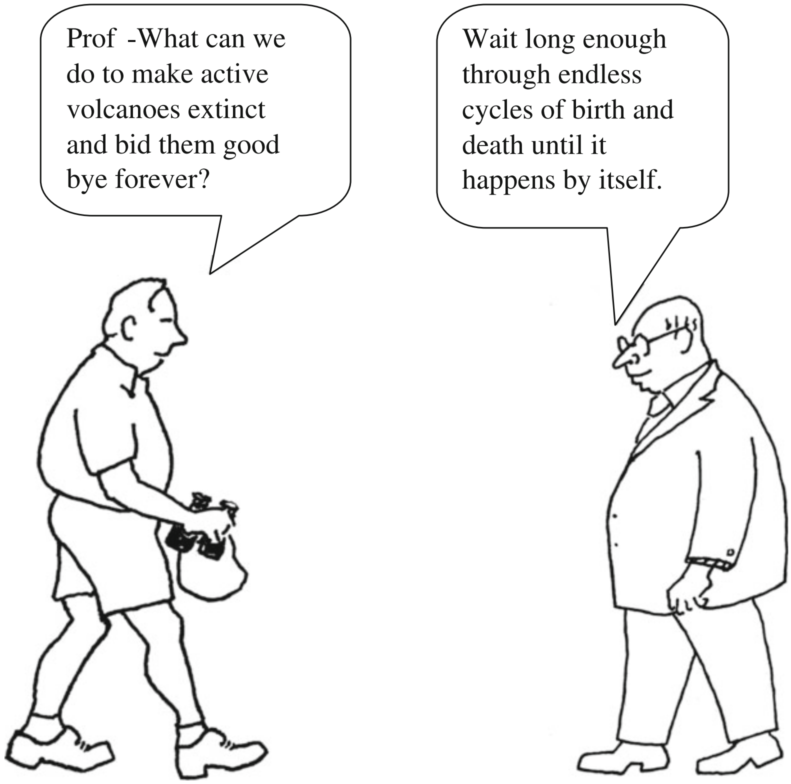


Fig. 3.4 A volcano can be active for several million years within which we may have the phases of volcanic eruption punctuated by centuries of inactivity. Volcanic belt and the orogenic belt more or less coincide. The subduction zone shows seismic activity for tens of millions of years, and fear of volcanoes is known to persist for the entire period of the subduction zone activity. No eruption is normally expected in a volcano designated as an extinct volcano but eruption of an extinct volcano cannot be completely ruled out

A Scale for Ranking Volcanic Eruptions

See Fig. 3.5 for details.

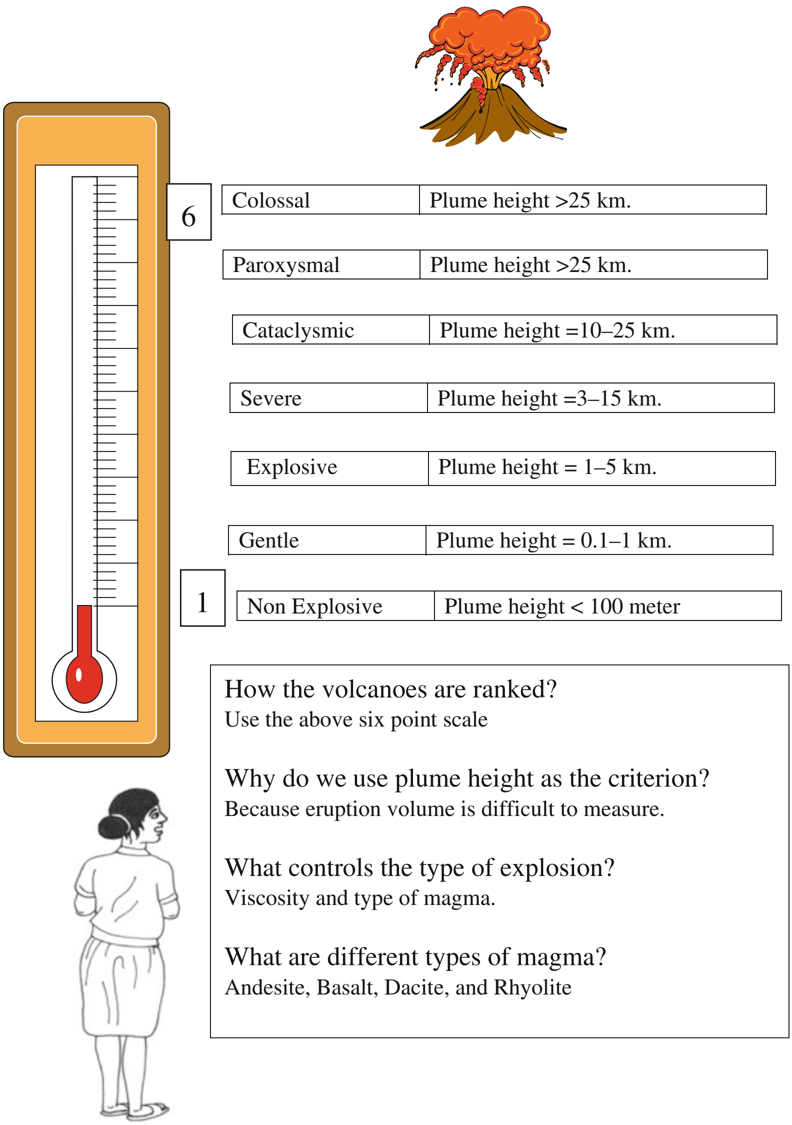
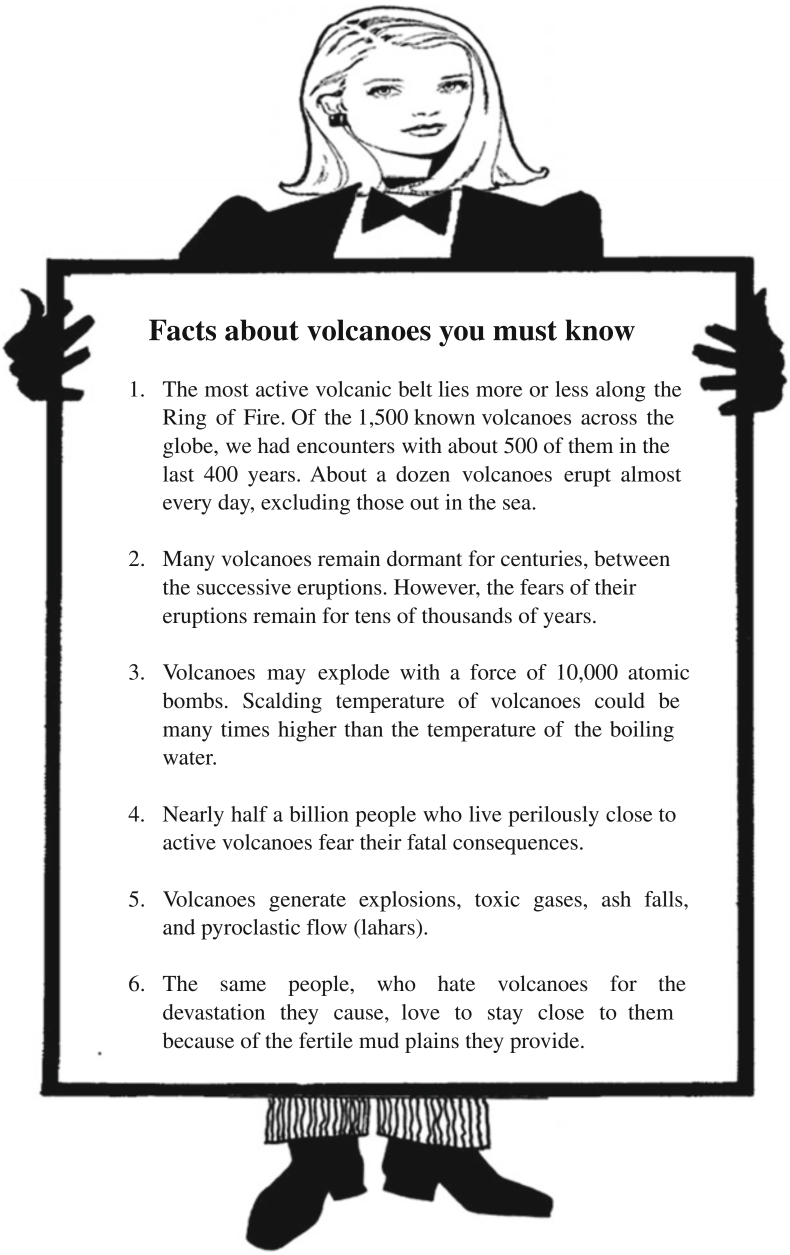


Fig. 3.5 A six-point scale to rank volcanoes power of eruption in terms of Volcanic Explosively Index (1–6) and the Plume height



Facts about volcanoes you must know

1. The most active volcanic belt lies more or less along the Ring of Fire. Of the 1,500 known volcanoes across the globe, we had encounters with about 500 of them in the last 400 years. About a dozen volcanoes erupt almost every day, excluding those out in the sea.

2. Many volcanoes remain dormant for centuries, between the successive eruptions. However, the fears of their eruptions remain for tens of thousands of years.

3. Volcanoes may explode with a force of 10,000 atomic bombs. Scalding temperature of volcanoes could be many times higher than the temperature of the boiling water.

4. Nearly half a billion people who live perilously close to active volcanoes fear their fatal consequences.

5. Volcanoes generate explosions, toxic gases, ash falls, and pyroclastic flow (lahars).

6. The same people, who hate volcanoes for the devastation they cause, love to stay close to them because of the fertile mud plains they provide.

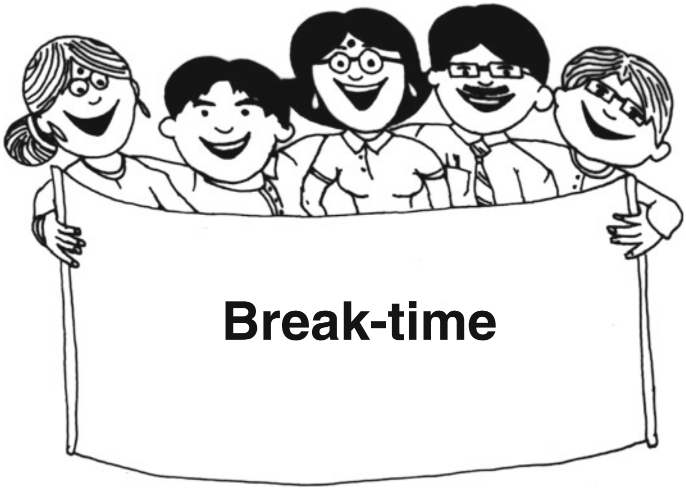
Glimpse of a Great Volcano

St. Helens volcano in the Washington State of the United States of America exploded on 18 May 1980. Strangely, it exploded sideways and not vertically upwards as we normally expect volcanoes to do. The eruption created a 5 km long fracture, and toppled trees up to the distance of about 30 km. Nearly 1.6 billion board feet of commercial timber and numerous fisheries in the area were badly affected.

> Some of the victims died purely because of bad luck, others out of ignorance or because of misinformation. I just thought some little puff of smoke would come out and lava will dribble down, said a survivor. One couple was killed as they watched the eruption from a viewpoint 25 miles away. Search crews found some victims still clutching cameras, exemplifying human characteristics that, for better or worse, set the human species apart from all others; stubbornness so entrenched that it defies all commonsense, and curiosity so consuming that it continues to be very abyss.
>
> See Carson (2002), p. 143.

Men for Whom the Volcanoes Were Their First Love

- Christian Leopold Von Buch (1774–1852), an outstanding geologist of all times, is credited for the earliest pioneering studies on volcanoes. He was contemporary to the famous geologist and geographer Alexander von Humboldt.
- James Hutton (1726–1779), an eminent Scottish Geologist, was first to fall in love with both intrusive and extrusive volcanic rocks and to trace their igneous origin. He continues to be remembered for his masterpiece publication *The theory of the Earth*, published in 1785–1788.
- Thomas Jaggar and Frank Perret, both American volcanologists, were the first to establish a Volcanic Observatory in 1911 right at Hawaii's Kilauea caldera. The former is famous also because of the Jaggar Museum whereas the latter is best known for his insightful studies during the 1929–1932 eruption of Mt. Pelée on Martinique in the Caribbean.
- Peter William Francis (1944–1999), a British volcanologist, was one of the early pioneers in volcanological remote sensing and in the application of spectroscopic techniques to the measurements on volcanic gases. He also studied volcanoes on other planets. Extremely popular for his art of communication, he is hugely remembered for his book on volcanoes, published by Penguin in 1976 and for his book *Volcanoes: a Planetary Perspective* published by Oxford University Press.



Break-time question 1: If volcanoes are so awesome and dangerous, why people continue to live so close to volcanoes in the forbidden zone?

Answers to break-time question 1

See Fig. 3.6 for details.

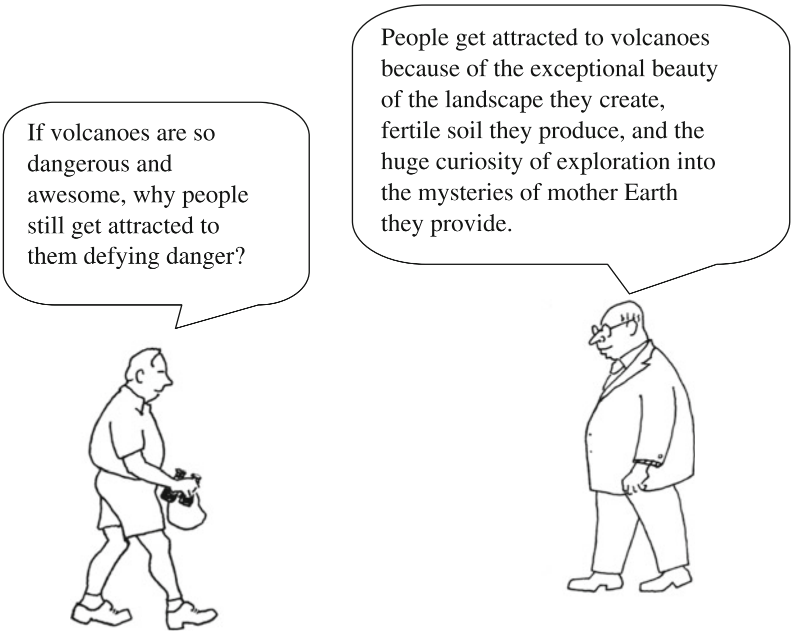


Fig. 3.6 In spite of these dangerous volcanic phenomena, more than 40,000 people are still living in the so called *forbidden zone*. It is undoubtedly the fertility of the ground that they are reluctant to leave this danger area, although the government has offered them better (safer) places to stay on other islands in Indonesia (Ismangun 1978)

Earthquakes

See Figs. 3.7 and 3.8 for details.

Terminology

Earthquake
An earthquake is trembling of the ground produced by the sudden release of energy in the rock masses, accumulated as locked-in stresses along a tectonic fault plane, within the Earth's crust or its upper mantle.

Focus or hypocenter
Hypocenter is the point on the fault plane where slip leading to occurrence of the earthquake starts, Figure 3.7.

Epicenter
Epicenter is the point on the Earth's surface which is vertically above the hypocenter or focus of an earthquake, Figure 3.7.

Depth of an Earthquake

By depth of an earthquake we mean the depth of focus or hypocenter from the earthquake epicenter. The depths of earthquakes do vary from earthquake to earthquake because of the variable geology and seismicity of the areas, Figure 3.8.

Classification of Earthquakes according to Focal Depth

Shallow ……………………<70 km
Intermediate ……………70 km–300 km
Deep ………………………..300 km–700 km

Examples

Earthquakes in Himalayas…….Shallow
Earthquakes around Pacific….Intermediate/Deep

Damage Potential
Shallow earthquakes cause greater damage.

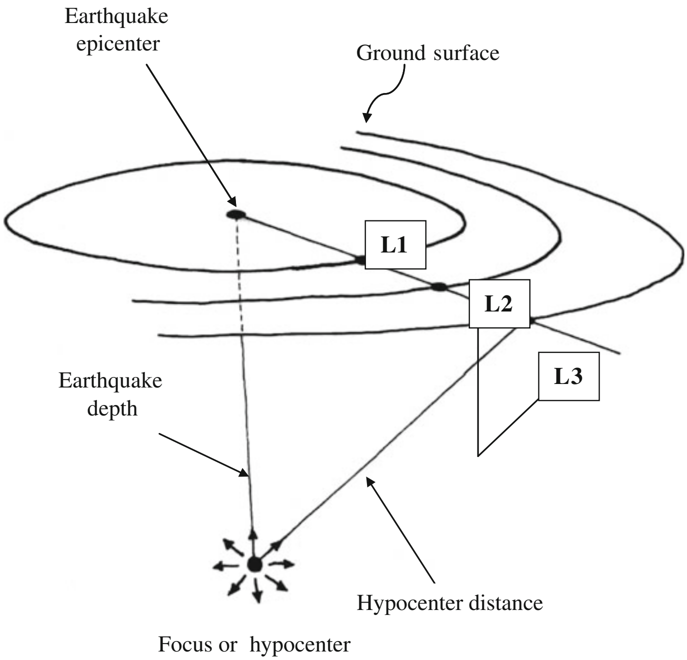


Fig. 3.7 The sketch illustrates the terms earthquake focus (also called hypocenter) and earthquake epicenter in relation to the locations *L1*, *L2,* and *L3* of the observers

Fig. 3.8 The interior of the Earth is quite similar to the structure of an onion and its layered interior. The uppermost layer of the Earth is called crust with average thickness of about 35 km in the continents. In the oceanic region, the crust thickness reduces to just about one-fifth, to about 7 km. Below the Earth's crust lies the upper mantle about 670 km thick. It follows therefore that focal depth of shallow earthquakes being less than 70 km, most of these occur close to the Earth's crust. The focal depths of deep earthquakes lie between 300 and 700 km depth that is in the lower regions of the upper mantle. Intermediate earthquakes occur at depths between 70 and 300 km

Earthquake Waves

Earthquake waves get generated when the slip on a geological fault plane within the lithosphere causes release of internal energy in the rockmass. The earthquake (seismic) waves so generated travel through the rockmass to long distances. They are called *body waves* because they travel within the body (interior) of the Earth. The two main types of body waves are called Primary and Shear waves or popularly known as P and S waves. When the body waves arrive near the ground surface, additional waves are generated. These additional waves are called surface waves or more specifically, Love and Rayleigh waves.

Primary Waves

The compression waves or primary waves are called P waves. They are the fastest of the earthquake waves. Being the fastest, these waves are the first ones to arrive and give us the first earthquake jolt. These waves travel through solid rock masses at a speed of about 4.8 km/s and slow down to about 1.4 km/s while passing through water. Denser the media, faster is their speed.

Shear Waves

A Shear or S wave is slower than a P wave and can only travel through solid rock and not though water. It causes buildings to vibrate from side-to-side. S waves are the main cause of damages to the buildings because the side-to-side (horizontal) motion they cause is more harmful than vertical motion of the ground. Denser the media, faster is their speed. S waves travel at 3 km/s.

Love Waves

It is the faster of the two surface waves and moves the ground from side-to-side.

Rayleigh Waves

A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down and side-to-side in the direction of the wave. Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

Distance to an Earthquake

The distance of the epicenter of an earthquake from the location of an observer is estimated from the record of arrival times of P and S waves, and finding the time lag or the difference between their arrival timings.

Patrick L. Abbott considered the seismogram of the great Sumatra earthquake of December 2004 recorded in Finland. The difference between the travel time of S and P waves at the station was found to be 11 min. He estimated the distance from the station in Finland to the earthquake epicenter in Sumatra as 8,800 km. For this

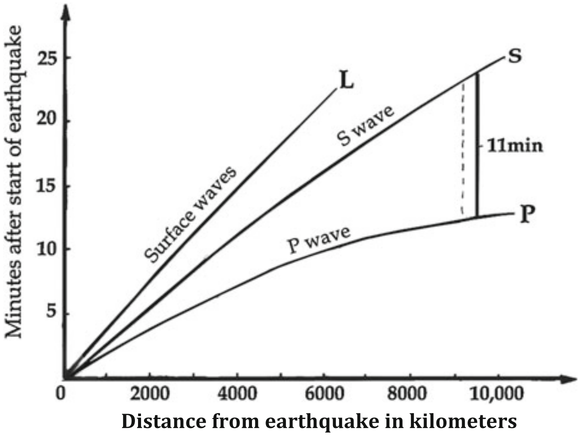


Fig. 3.9 The time–distance graph shows relationship between the times since the occurrence of the earthquake and the distance traveled by P and S waves. *Source* Abbott (2003)

estimation, he first located the point on the above nonlinear curve at which the time difference of 11 min was the best fit. The epicenter distance could then naturally read on the X-axis, Fig. 3.9.

Step-by-Step Procedure to Find the Location of an Earthquake from a Seismic Station

1. Seismic stations provide records of seismograms of an earthquake to the observer. P waves are first to arrive on the seismogram followed by S waves. By noting the arrival times of P and S waves, we can find the difference in the arrival times, called the *lag time*.
2. The next step is to use the information on the lag time determined in step 1 above, to locate the best fit point on the time–distance curve for P and S.
3. The distance to the point identified in step 2 above, will give the distance to the epicenter of the earthquake from the seismic station.

We need much more information to determine the exact location of the earthquake epicenter. For this purpose:

- We need more seismographic records from at least three or more seismic stations. This will make it possible for us to determine distances to the epicenter from every seismic station.
- We then regard the locations of seismic stations as the centers of circles drawn with the distances to epicenters as the radii.
- The point that satisfies the three or more circles is the location of the earthquake epicenter. A rule of thumb to find the distance to an earthquake is given in Fig. 3.10.

Fig. 3.10 A rule of thumb to find the distance to an earthquake

Earthquake Magnitude, Duration, and Damage Potential

Earthquake Magnitude

Earthquake magnitude is a measure of its strength calculated from the record of that earthquake seismograph. Charles F Richter, a seismologist from California was the first to calculate earthquake magnitude, as the logarithm to the base 10, of the maximum amplitude of the seismic wave measured on a seismograph at a distance of about 100 km from the earthquake epicenter.

Scale to Measure the Strength of an Earthquake

Charles Richter in 1935 gave us Richter scale to measure the size of an earthquake in terms of its magnitude, Fig. 3.11. He found the need to invent the scale because he got tired of the journalists who often asked him to compare earthquakes in terms of their sizes.

Duration of an Earthquake

A small earthquake may shake the ground for less than a second, a moderate earthquake may shake the ground for a few seconds but major earthquakes generally last for tens of seconds to a few minutes. The duration of an earthquake depends on its magnitude, type of rock, length of geological fault, and the distance to the epicenter. The Sumatra earthquake of December 2004 is an example of an earthquake that lasted as much as 500–600 s. In most cases, duration of an earthquake has a telling effect on the magnitude of damage.

Damage Potential

Earthquake magnitude	Anticipated damage
Up to 3	No damage
3–3.9	Some cracks in mud houses
4–4.9	Minor damage
5–5.9	Moderate damage
6–6.9	Severe damage and collapse
7–7.9	Extreme levels of damage

Determining the Magnitude (Size) of an Earthquake

The magnitude of earthquake can be determined by using the following nomogram attributed to Hays (1980). You will require scaling out from the seismogram the time difference in the arrival times of P and S waves and the value of maximum amplitude (Fig. 3.11).

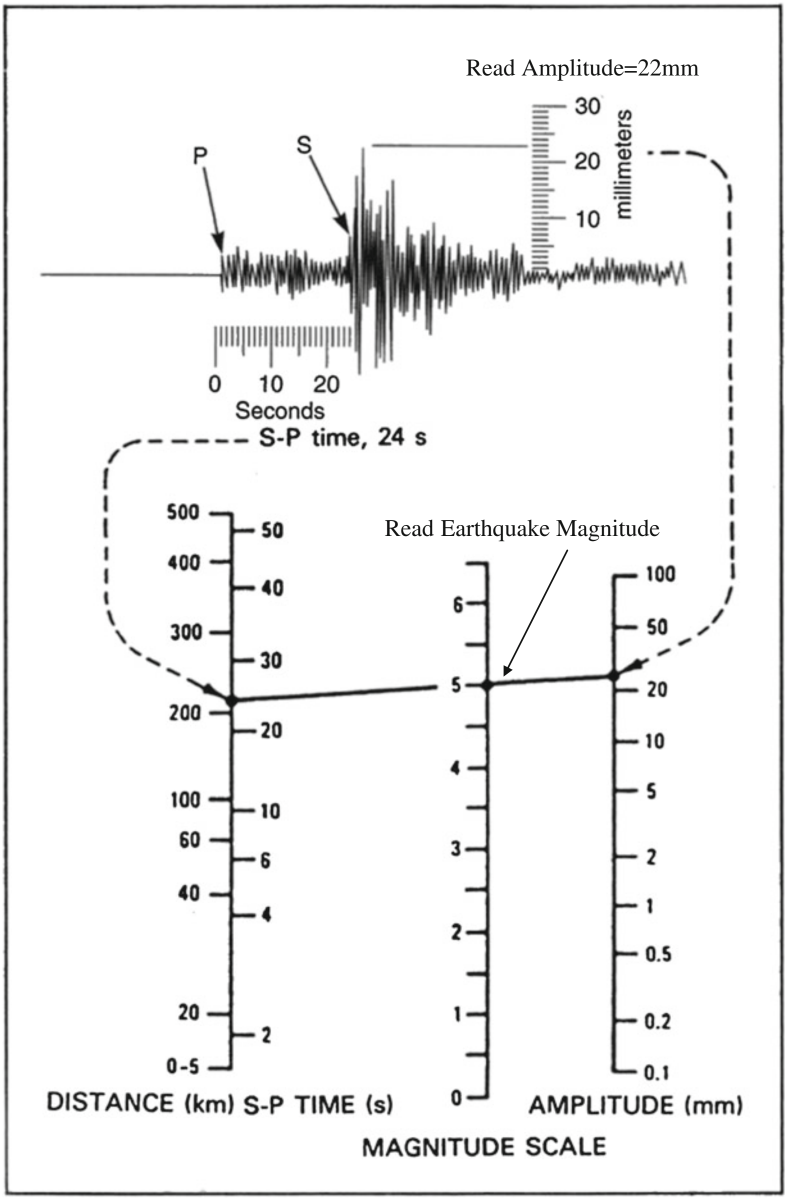


Fig. 3.11 Nomogram to find the magnitude of an earthquake

Earthquakes Versus Atomic Bombs

Students will find it educative to compare energies released in an atom bomb explosion and that released by an earthquake. Figure 3.12 assumes the energy released by an earthquake of magnitude 4 as a base.

$$\frac{\text{Energy released by the earthquake of magnitude 7}}{\text{Energy released by the earthquake of magnitude 4}} == \mathbf{32{,}000}$$

$$\frac{\text{Energy released by the earthquake of magnitude 9}}{\text{Energy released by the earthquake of magnitude 4}} == \mathbf{32{,}000{,}000}$$

- ✓ The 1964 Great Alaskan earthquake of magnitude 9.2 released 450,000,000,000,000,000,000,000,000 ergs of energy.
- ✓ An earthquake of magnitude 9 is expected to release energy equivalent to 50 megaton H-bombs.
- ✓ An earthquake of magnitude 6 is equivalent to an atomic bomb of 20,000 tons of TNT

Fig. 3.12 For increase of an earthquake magnitude by 1, its energy level changes 30-fold. Energy release at the focus of an earthquake is related to its magnitude by equation $\log E$ (ergs) $= 11.8 + 1.5$ M

A Glimpse of the Bizarre World of Earthquakes

One minute is a very small length of time for us but for an earthquake, one minute is a very long length of time. An earthquake of duration less than one minute is enough to destroy what we take generations to build.

In a sense, the six letters of the word MINUTE convey a lot about earthquakes as shown below (Fig. 3.13):

M	I	N	U	T	E
Magnitude	Intensity	Number/yr	Umbrage	Tag	Example
8	XI-XII	One	Total Damage	Great-	Shillong 12 June 1897
7-7.9	IX-X	18	Heavy Damage	Major-	Tangshan 28 July 1976
6-6.9	VII-VIII	120	Substantial	Strong-	Northridge 17 Jan 1994
5-5.9	VI-VII	800	Some Damage	Moderate-	Hindukush 12 April'02

Fig. 3.13 Tangshan earthquake of 28 July 1976 of magnitude 7.5–7.8 struck northern China at 03:42 am, lasting no more than 16 s, killing 250,000 people. Great earthquakes shake ground for 30–90 s; major earthquakes for 30–50 s; strong earthquakes for 10–30 s, and a moderate earthquake for 2–15 s

An Earthquake Which Killed 250,000 People in 16 Seconds!

Tangshan earthquake of 28 July 1976 in the northern China created a seismic history and a big human tragedy at the same time, Fig. 3.13. It struck with magnitude of 7.8 marginally falling short of the qualifying mark of a great earthquake and yet the blow it delivered in just a matter of 16 s, surpassed what many great earthquakes could not do even with strike time of 30–90 s. One might ask what is its story?

The earthquake chose to strike at 03:42 am when most people were fast asleep. Even for those who found a window of opportunity to escape, the aftershock of magnitude 7.1 that followed the main shock of magnitude 7.8 blocked their way to safety. Residential, commercial, and hospital buildings collapsed like a deck of cards killing and injuring thousands. Medical men themselves became victims with hardly any one left to help people crying for medical help. Industrial buildings performed slightly better, nonetheless nearly two-thirds of them also collapsed. The entire city of Tangshan was razed to ground with thousands buried under the heaps of debris.

It was extraordinary that amidst all this, the same earthquake spared the night shift coal miners working hundreds of meter below ground level. Nearly three-fourths of those trapped could be exhumed and saved, although the rescue operations got a big jolt when an aftershock of magnitude 7.1 struck in the afternoon of the 28 July.

The night of 27 July was unusual according to eyewitness reports. Strange lights, fire balls, and lightning were seen across the skies. Loud and roaring noises were heard. Animals were found to be restless. The night was both rainy and windy. Even with these indicators, the earthquake dodged the Chinese scientists who had, a few months earlier, surprised the world with their successful prediction of the Haicheng earthquake.

This earthquake will remain unforgettable also because it showed that what men took centuries to build could be destroyed just in a few seconds. Also, an event of magnitude 7.8 can do more damage than a Great earthquake if it decides to strike when most people are asleep.

Difference Between Magnitude and Intensity of an Earthquake

Magnitude of an earthquake is the measure of its size. Its intensity is the measure of its observed severity based on the observed effects such as damage to human settlements and the infrastructure. In America and Western Europe, the Modified Mercalli (MM) scale is used to read earthquake intensity in terms of damage levels. The Medvedev–Sponheuer–Karnik (MSK) scale is popular in Eastern Europe. The Indian Code IS 1893 Part 1 refers to 12 categories of damage as detailed out in the table below:

Intensity	Damage
I and II	Unnoticeable to scarcely noticeable
III	Partially observed
IV	Widely observed
V	People get scared and buildings tremble
VI	Frightening
VII	Frightening and damaging
VIII	Destructive
IX	Panic and widespread damage
X	General destruction
XI	Catastrophe
XII	Landscape change

The concept of earthquake intensity is explained in Fig. 3.14 and a feel of an earthquake is provided in Fig. 3.15 which shows the frightened people struck by an earthquake of intensity VI (also see Figs. 3.16 and 3.17).

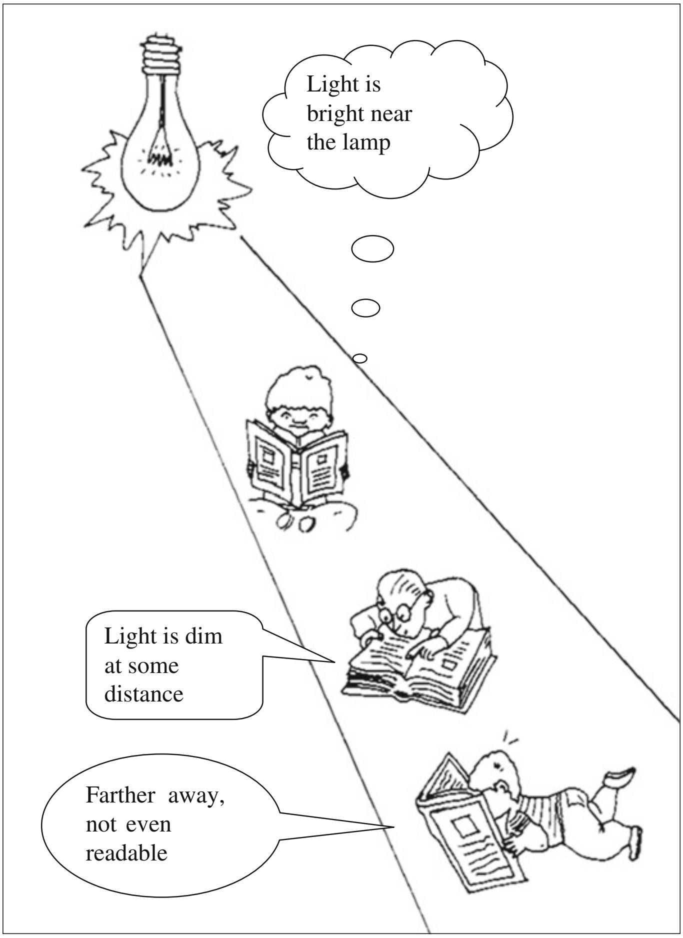


Fig. 3.14 The earthquake intensity for a particular earthquake magnitude decreases from the source of an earthquake the same way as the intensity of light decreases with increase of distance from the bulb of a particular power

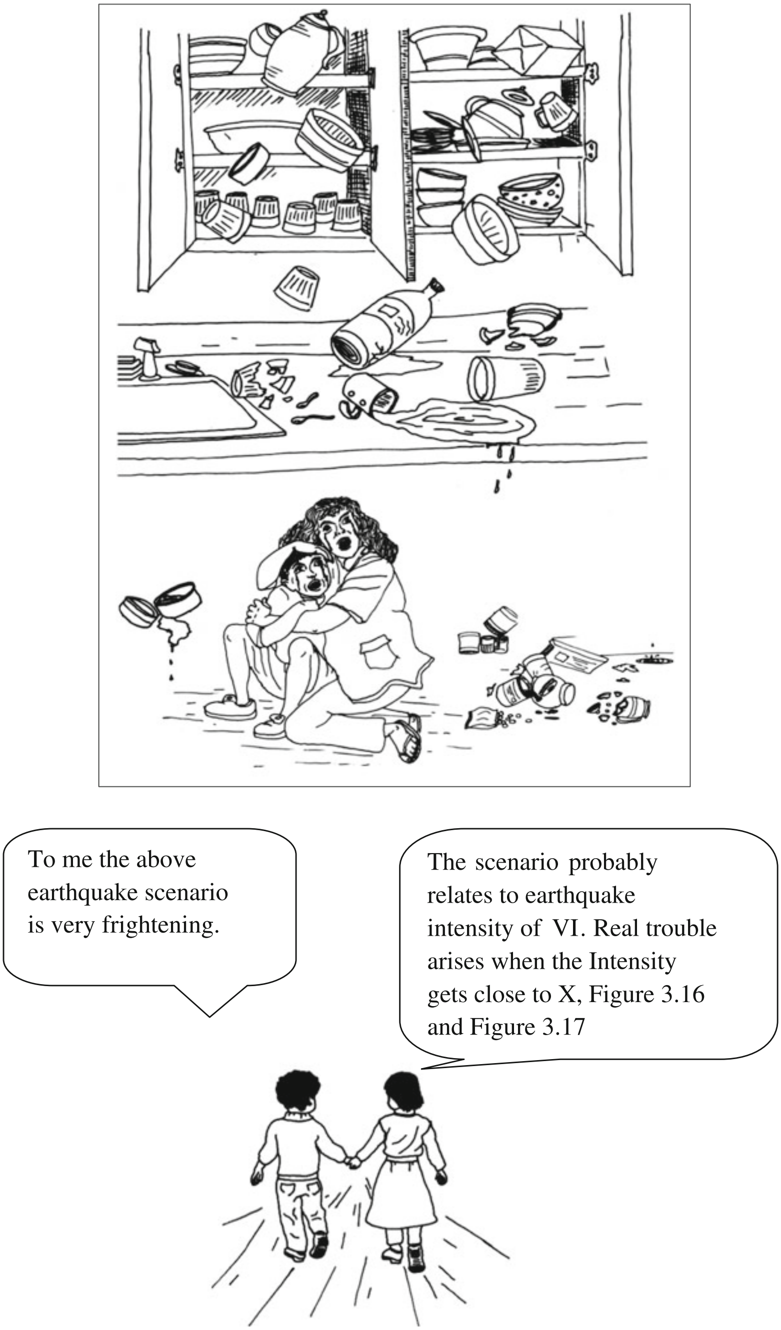


Fig. 3.15 A feel of an earthquake tremor

Fig. 3.16 A hotel in Gandhi Nagar collapsed during the Gujarat earthquake of 26 January 2001. This was entirely avoidable had the building design been faithful to the design codes for seismic zone V of the seismic zonation map of India

Fig. 3.17 View of a building in Gandhidham, Gujarat which collapsed like a deck of cards during the earthquake of 26 January 2001. This type of building collapse is typical of building failures due to the loss of support between the floors

Your Chance to Feel a Great Earthquake

Richard Dixon Oldham (1858–1936) was the first to distinguish between the Primary and the Shear waves. He was also the first one to point out during earthquake measurements that P waves from an earthquake may not get detected in certain parts of the globe because of the possible bending of the seismic waves. The bending was attributed by him to the seismic shadow cast by the Earth's core. His monumental work on the Great Shillong earthquake of 1897 and his eyewitness account of that earthquake, reproduced below, bear stamp of his yeoman's service to the Geological Survey of India.

On the 12 June 1897, my wife and I were sitting in the verandah of the Chatgari rest house waiting for a slight shower of rain to stop. At 5:13 pm, we were suddenly startled by a very vivid flash of lightning followed by a tremendous crack of thunder. At the same time, the bungalow began to tremble slightly. This, I at first put down to the thunder, but as the trembling motion began to increase, I cried out that it was an earthquake. The motion began getting more and more violent, and as the timbers all began to crack and the verandah floor to split under our feet, I hurried my wife outside into the rain, which was coming down in torrents. It was as much as I could do to hold my wife up. We then saw the earth all round heaving in a most frightful manner. The earth resembled waves coming from opposite directions and meeting in a great heap and then falling back; each time the waves seemed to fall back, the ground opened slightly, and each time they met, water and sand were thrown up to a height of about 18 inches or so. This shock lasted for about three minutes, I should think. There was no rumble with it. The shock was strong enough to knock over a couple of elephants I had in the camp with me. My horse too in the stable was knocked off his legs and my dogs could not stand up in the verandah of the bungalow…

See Oldham (1899), P. 26

Global Annual Count of Earthquakes

See Figs. 3.18 and 3.19 for details.

Group	Magnitude	Annual average number
Great	8 and higher	1
Major	7–7.9	18
Strong	6–6.9	120
Moderate	5–5.9	800
Light	4–4.9	6,200
Minor	3–3.9	

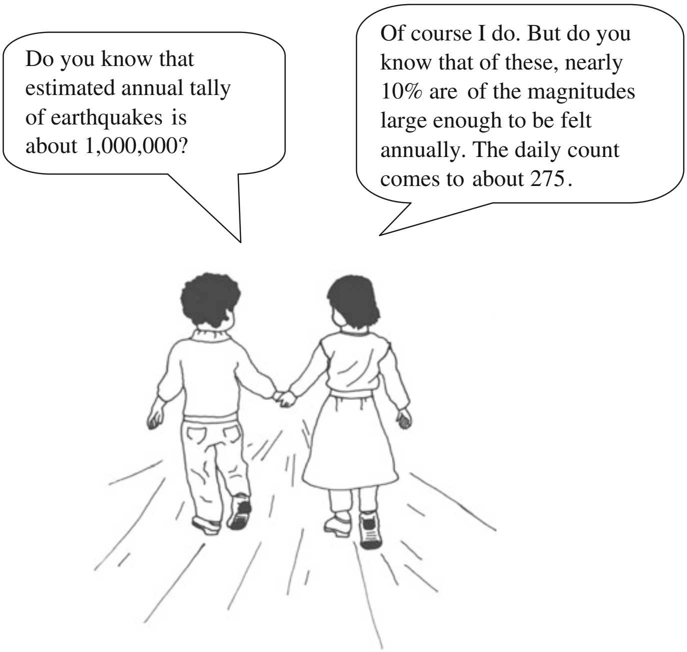


Fig. 3.18 Global count of earthquakes

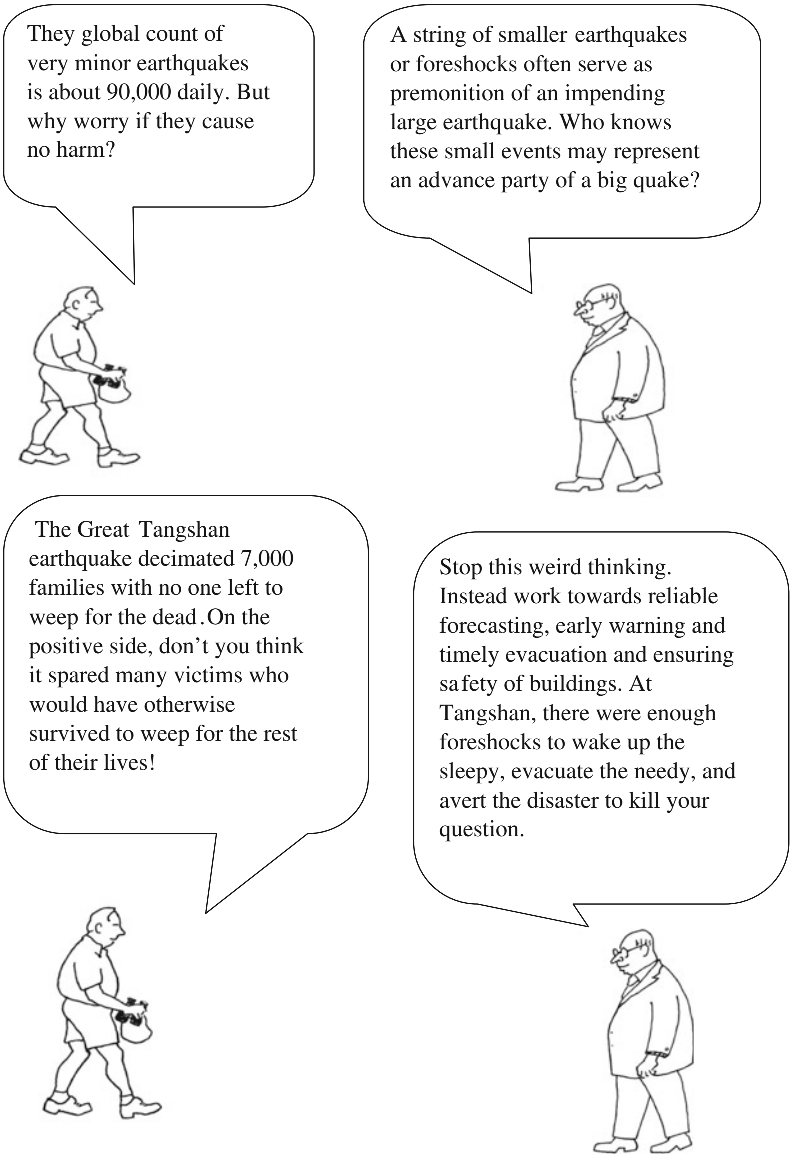


Fig. 3.19 Food for thought

Earthquake Classification

Plutonic Earthquakes

Plutonic earthquakes occur at great depths. They owe their origin to abrupt volume changes caused by phase transformation of some rocks because of very high pressures and temperatures deep inside the Earth.

Interplate and Intraplate Earthquakes

Interplate earthquakes occur along the boundaries of tectonic plates. Most earthquakes of the world fall in this category. Intraplate earthquakes, however, occur within the plate itself, away from the tectonic plate boundaries. The Latur earthquake of 1993 in India is an example of intraplate earthquake that surprised many seismologists across the globe.

Cluster Earthquakes

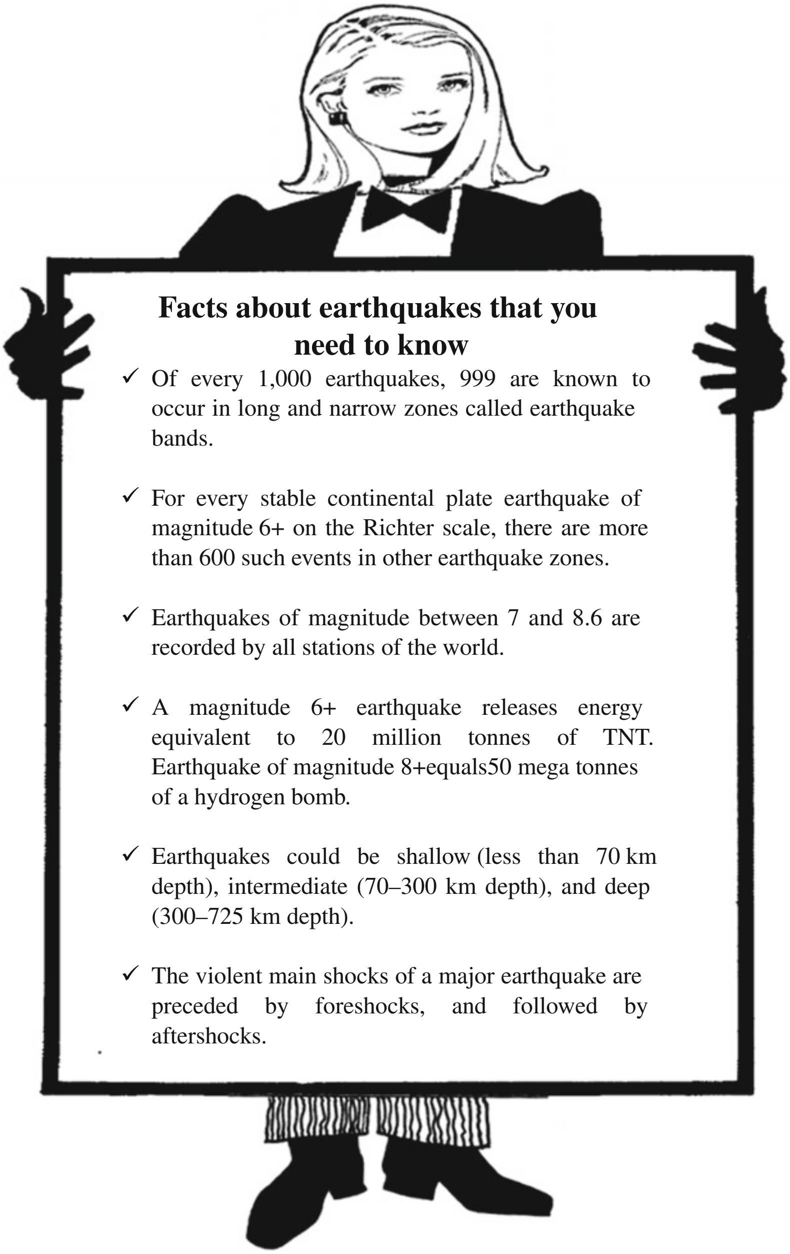
Moderate to large earthquakes sometimes occur in clusters.

Swarm Earthquakes

Swarm earthquakes are a large number of small and medium earthquakes without any outstanding main earthquake event. They are generally shallow earthquakes caused due to localized stresses in a highly heterogeneous medium.

Micro Earthquakes

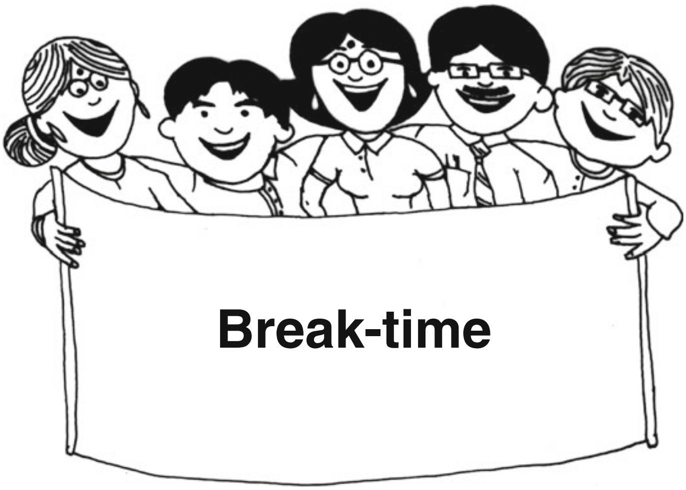
Micro earthquakes or micro tremors have been defined as earthquake shocks having magnitudes ranging between $1 \leq M \leq 3$. These are normally shallow depth events with focal depths of around 10 km.


Facts about earthquakes that you need to know
✓ Of every 1,000 earthquakes, 999 are known to occur in long and narrow zones called earthquake bands.
✓ For every stable continental plate earthquake of magnitude 6+ on the Richter scale, there are more than 600 such events in other earthquake zones.
✓ Earthquakes of magnitude between 7 and 8.6 are recorded by all stations of the world.
✓ A magnitude 6+ earthquake releases energy equivalent to 20 million tonnes of TNT. Earthquake of magnitude 8+equals50 mega tonnes of a hydrogen bomb.
✓ Earthquakes could be shallow (less than 70 km depth), intermediate (70–300 km depth), and deep (300–725 km depth).
✓ The violent main shocks of a major earthquake are preceded by foreshocks, and followed by aftershocks.

The Men Who Caused Tremors!

- Chang Heng, a Chinese scientist, was the first to invent a seismoscope in AD 132. It was meant to serve as an instrument to record the occurrence of an earthquake. Heng's seismoscope was called dragon jar. It was a cylindrical jar with eight dragonheads arranged around its brim. Each dragon had a ball in its mouth. Around the foot of the jar were eight frogs, each directly under a dragonhead. Whenever an earthquake struck, a ball dropped from a dragon's mouth to the frog's mouth.
- Charles Richter (1900–1985) was the first to give us the Richter scale on which we measure earthquakes. Jointly with Beno Guttenberg (1880–1916), the design of the scale was rooted in the seismographic recordings. The scale begins with zero, and with the next step on it representing a 30-fold increase in the earthquake energy.
- Andrija Mohorovicic, a Croatian Geophysicist (1857–1936), was the first to detect the boundary between the crust and the mantle of the earth. When an earthquake struck Zagreb in 1909, he observed that some seismic waves arrived faster than others. He attributed this to the change in density within about 30 km from the Earth's surface. The interface is now commonly known as Mohorovicic discontinuity, or Moho.
- Edwin Aldrin, the *Apollo* 11 Astronaut was the first to place a seismograph on the surface of the Moon in 1969.
- A. E. H. Love, a British mathematician was the first to identify Love waves transmitted by an earthquake and developed a mathematical model to explain it in 1911.
- Lord Rayleigh was the first to mathematically predict the existence of Rayleigh waves in 1885
- John Milne (1850–1913), the famed English seismologist and mining engineer was the first to invent the modern seismograph for earthquake detection in early 1890s. It was improved after World War II with the Press–Ewing seismograph, developed in the United States which uses a Milne pendulum, but the pivot supporting the pendulum is replaced by an elastic wire to avoid friction.
- Luigi Palmieri of Italy was the first to design a mercury seismometer in 1855. Palmieri's seismometer had U-shaped tubes filled with mercury, arranged along the compass points. With the strike of an earthquake, the mercury in the U-tube made an electrical contact which stopped a clock and started recording the motion of the float on the surface of mercury on the drum. This was the first device ever to record the time of the earthquake and the intensity and duration of the earthquake motion.
- Michele de Rossi of Italy (1874) and Francois Forel of Switzerland (1881) are jointly credited for the first modern earthquake intensity scale. They independently published similar intensity scales about the same time. Rossi and Forel later collaborated and produced the Rossi–Forel Scale in 1883. The Rossi–Forel Scale used 10° of intensity and became the first scale to get an international acclaim.

- In 1902, Italian volcanologist Giuseppe Mercalli created a 12° scale of intensity for measuring earthquakes. Despite a number of other intensity scales available for use, Modified Mercalli (MM) Intensity Scale, developed in 1931 by the American seismologists Harry Wood and Frank Neumann, is still being used. This scale, demarcated in 12 Roman numerals conveying increasing intensity levels cover earthquake shaking from imperceptible to catastrophic levels. It is an arbitrary scale developed on the basis of observed effects.



Break-time question 2: How can we explain occurrence of earthquakes at very large depths despite ductility at temperatures exceeding 2900 °F and pressures exceeding 240,000 times those at the surface of the Earth?

Answer to Break-time question 2

The question why earthquakes do also occur at large depths has been haunting the seismologists and geophysicists for decades. It is apt to quote William J. Broad[1]:

> The mystery is how earthquakes happen at all at remote depths where temperatures may exceed 2900 °F and pressures are 240,000 times greater than those at the surface of the Earth. In theory, any rock there should have the consistency of putty, ruling out the brittle fracture and frictional sliding found in faults near surface. This paradox has been one of the main problems of geophysics ever since the remarkable depth of some earthquakes was first recognized seven decades ago.

We can probably understand earthquakes occurring at depths of 200–300 km, where rock can fracture being cold and brittle. At deeper depths, rocks are ductile (not brittle) and normally one would expect such rocks under exceptionally high confining pressures to flow and deform rather than fracture. One possible argument usually advanced is that at deeper depths one finds layers of crystals undergoing phase transformation from the olivine structure to the denser spinel structure. This is a subject wide open for research for you to find a more convincing answer.

Tsunami

Tsunami is a Japanese term made of two words, *tsu* + *name*. The word *tsu* means *harbor* and the word *name* means a *wave*. Literally translated, tsunami means a sea wave or a harbor wave. The term was coined by the Japanese fishermen. Look at it as it approaches the coastline and destroys all that is there, Figs. 3.20 and 3.21.

[1] Quoted in Nicholas (1995).

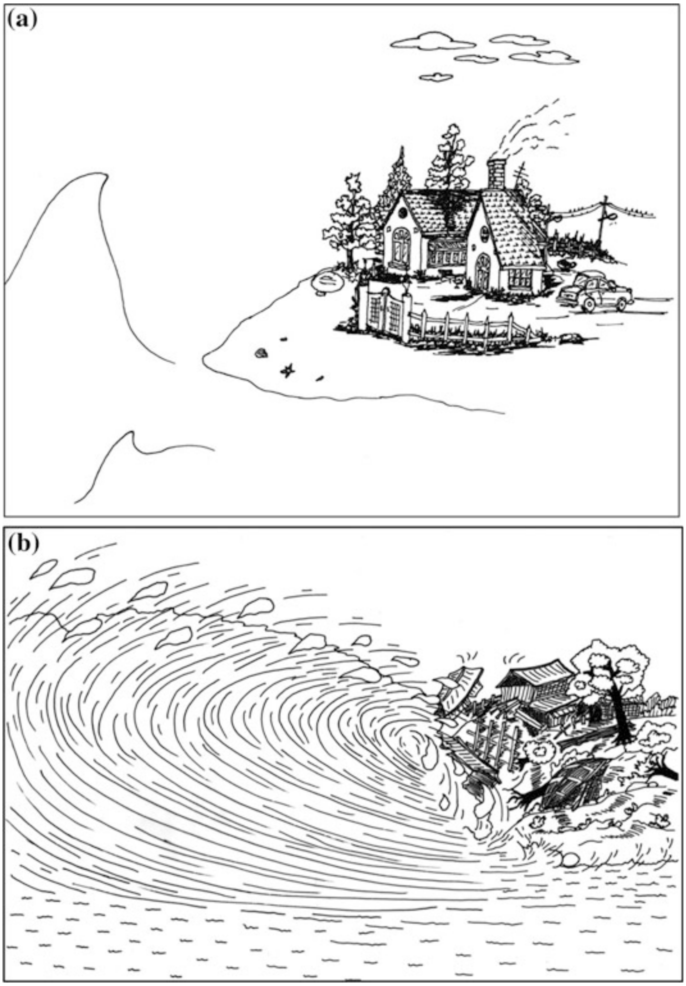


Fig. 3.20 An artist's view of tsunami waves hitting a coast. **a** A giant tsunami wave is seen approaching a sea coast. Timely tsunami warning made the evacuation possible. **b** This is what really happened after the waves hit the coast

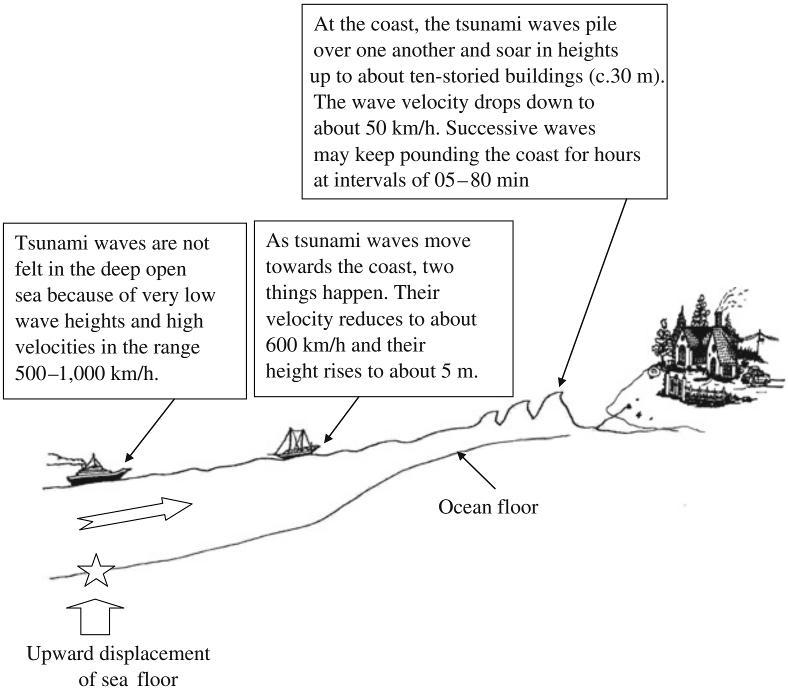


Fig. 3.21 Tsunamis come and go and sea rediscovers itself to innocence. Commenting on the famous Indian Ocean tsunami of December 2004, The Island, a local newspaper of Sri Lanka wrote on 14 January 2005: “The Sea has calmed down and wears an innocent look as if it never committed any crime”

Tsunami Wave Train

A typical tsunami looks like a wave train, Fig. 3.22. When in the open deep sea, the waves of the train have large wavelengths and low amplitudes, but as the wave train approaches a coastline, the wavelengths reduce and wave heights soar up. This is the reason that the Japanese fishermen who felt nothing out while fishing in the deep sea, were stunned to find massive devastation caused by the tsunami waves upon returning to the sea coast.

What Causes a Tsunami?

Tsunami waves are triggered by factors such as massive undersea earthquakes, coastal earthquakes, submarine landslides, and volcanic eruptions. All of the above events have at least one thing in common and that is the power to cause huge vertical and lateral movements of the sea bed which in turn displaces a huge body of the seawater generating large sea waves. The sea waves so generated hit coastal landmasses thousands of kilometers away.

The great Indian Ocean Tsunami of December 2004 was the result of a massive underwater earthquake. The 1958 tsunami in Alaska was the result of a massive rockslide at Lituya Bay in Alaska. The 1883 eruption of Krakatoa volcano in Indonesia was responsible for producing giant tsunami waves which killed over 36,000 people in Java and Sumatra. Tsunami waves must not be mistaken as tidal waves.

Difference Between Tidal and Tsunami Waves

The difference between the *ordinary* waves produced by fierce winds or tides, and the *extraordinary* tsunami waves is as great as the difference between hillocks and lofty mountains. In ordinary waves, the distance between the successive wave crests seldom exceeds quarter of a kilometer. The crest-to-crest distance of a tsunami wave may approach 100 km or even higher. Tidal wave speeds are usually low but tsunami waves may acquire speeds in the range 500–1,000 km/h. Only when the sea coast draws nearer, their speed finally reduce to as low as 50 km/h. Upon arrival at the coast, tsunami waves pile over one another and soar to wave heights, tides can never produce.

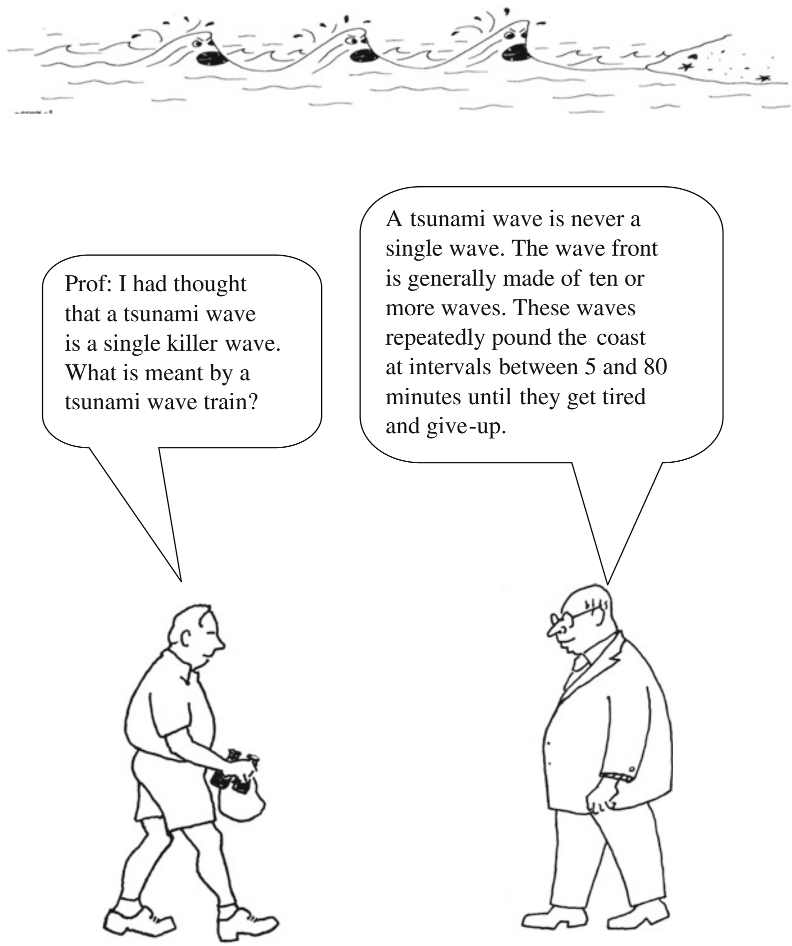


Fig. 3.22 The anatomy of a tsunami wave

Facts About Tsunamis You Need to Know

- Tsunamis have not spared any of oceans of the mother Earth but they love Pacific Ocean which is the home of nearly 85 % of tsunamis.[2] Mediterranean and Caribbean seas too have some history of tsunamis. In sofar as the Indian Ocean is concerned, tsunamis have been rare visitors but the devastating

[2] Pacific Ocean is also the home of nearly 85 % of the volcanoes. The tsunami count in the Pacific Ocean during the period 1900–1970 reached 180 and the present count may well exceed 800. Nine of these struck landmasses throughout the Pacific and 35 of them caused limited damage locally.

tsunami event of December 2004 came to suggest that it is a visitor not to be taken lightly.

- Tsunamis are seldom caused by earthquakes other than those with the hypocenter (focus) underneath an ocean or in its neighborhood. The chances of a massive underwater earthquake causing a tsunami are so great that a tsunami alert is normally sounded with every massive underwater earthquake.
- Underwater earthquakes of magnitude less than 6.5 seldom cause a tsunami and this is the reason that magnitude 6.5 is taken as the threshold for tsunami warning. An undersea earthquake of magnitude 7+ is invariably associated with a tsunami.
- A Tsunami usually provides an advance notice of its arrival in terms of the rapidly receding seawater. Do not ignore this signal.
- The roaring sounds of tsunamis should be taken as an alert and people should respond to it without any loss of time. This is particularly significant when it chooses to strike under the cover of darkness or at night when most people are asleep.
- The central message of every tsunami has been that when an alert is sounded, waste no time in moving on to a higher elevation away from the coastline because a fast incoming tsunami will otherwise soon overtake you, even if you are in the Usain Bolt category.
- Those on the coastline who fail to escape a tsunami, get literally sucked into the sea and some others may get killed because of the reasons such as drowning, crushing, collapse of buildings, and attack by the flying debris.
- It is not only that a tsunami inflicts damages when it invades the shore and inundates the coastline. A retreating tsunami may also cause substantial damage, because retreating tsunami waves do create a huge suction effect on the coastline leading to loss of soil support by scouring, and failure of foundations resulting in the collapse of harbor infrastructure and buildings.
- Topography of the sea floor, actual shape of the shoreline, and land morphology combine to make a huge difference in damage patterns. This is the reason that the level of devastation caused by a tsunami may be dramatically different in the two neighborhood areas. The message is clear. Do not interpret a small tsunami at your location to assume that all is well in the neighboring coastal township just because you are safe. The first wave of tsunami may not be the tallest in the tsunami wave train.
- Although buildings in low-lying coastal areas are rarely safe, it may not be a bad idea to move on to the top of the nearest and the tallest building, when you are without a better option.
- When in a boat, it may be wise to move away from the coastline toward the open sea. Be sure that the tsunami has passed off before returning to the coast.
- The first tsunami warning system was established in Hawaii, thanks to the 1946 Hilo tsunami. The Pacific Warning Center in Honolulu, Hawaii, is now well known for its very high degree of reliability and effectiveness. There are numerous success stories of the Tsunami Warning and of effective response, for example, during the tsunamis of 1952 and 1957 in Hawaii.

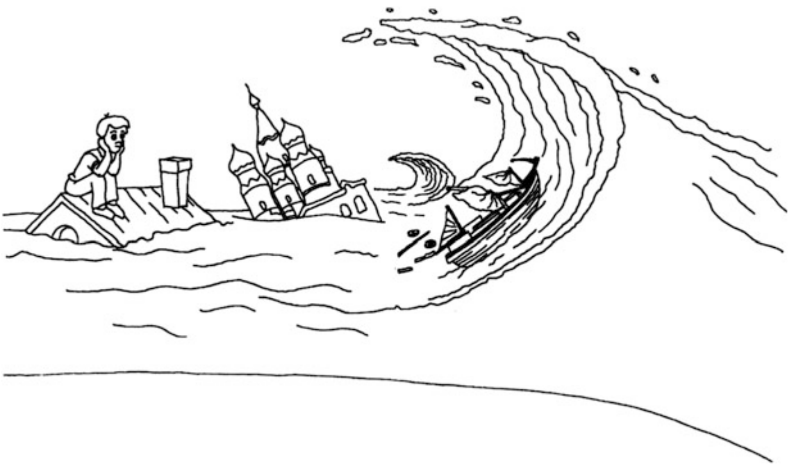


Fig. 3.23 An artist's visualization of a boy looking right in the face of a tsunami amidst the scene of gloom and doom

Story of a Rare Tsunami Event

"Out-of-Mind, Out of Sight," is an episode of a television serial *Buffy the Vampire Slayer.*[3] In one of its episodes, an invisible force attacks the people around. The deadly tsunami of which the story is being told, too was out-of-sight to the people of the Indian Ocean region for decades, until it struck in December 2004, out of the blue. The tsunami took away countless things from us but instead gave us an unforgettable story, almost a thriller in the Indian Ocean and gave us questions we must answer and the lessons we must not forget. Historically speaking, more than 790 tsunamis had struck the Pacific Ocean since 1900 but during the same period, only two tsunamis had occurred in the Indian Ocean which is why it went out-of-mind.

To the students of the region, tsunami as a geohazard was only being taught in the passing and many of them knew about it for the first time, Fig. 3.23. Geography and geology teachers hardly spent any time to discuss tsunami as a geohazard even for the senior students. Some of them believed that tsunami was for the people in the Pacific Ocean region to worry about. There were teachers who did not even know how the term tsunami is to be pronounced. What is a worse, disaster management plans in many countries of the region did not even mention tsunami as a likely threat.

The day the tsunami arrived to wake the *sleepy* Indian Ocean, it once again placed the Indian Ocean on the active tsunami map of the world. It was caused by an underwater earthquake of magnitude 9.3 off the west coast of northern Sumatra in Indonesia (3.3°N; 96.10°E). The strike time was UT 00:58:53 or 06:29 AM IST.

[3] *Source* Wikipedia.

So fierce was the tsunami event that it unleashed energy equivalent to 32,000 atomic bombs of the Hiroshima kind.

According to Geological Survey of India Memoirs 64 of 2005:

> At 0635 am local time, feeble tremors were felt that made many feel giddy. This was followed by strong to-and-fro shaking which lasted for almost 40 s. The time gap between the first feeble shocks and the following strong shocks was reported to be sufficient for most people to come out of their buildings even from second floor. No sound, however, accompanied the tremors. People ran outdoors in great panic; most people lost balance, fell or sat down and crawled out of their buildings. Those riding bicycles or motorbikes felt strong wobbling effect and therefore immediately stopped. Parked cycles and scooters fell down during strong shaking. A parked bus was visibly vibrating. Objects and utensils on racks were thrown. At a few places, heavy objects like steel almirahs and racks overturned. The total shaking has been reported by many to be of the order of 3 min or more.

The shores of the 13 countries including Indonesia, Sri Lanka, India, Thailand, Maldives, Somalia, Myanmar, and Malaysia were invaded by the tsunami and each one of them has its own set of stories to tell. These stories of the Indian Ocean tsunami are full of messages. The foremost message is that those who were alert enough and saw the receding sea as an early warning and those who took the radio news seriously and swiftly moved on to the higher locations, escaped death. Indeed, the tsunami gave sufficient forewarning to many countries in the sense that it reached their shores many minutes to several hours after it left the place of its origin. It gave people living on the Chennai coast of the Indian State of Tamil Nadu as many as 2.5 h. The Car Nicobar group of Islands got about 2 h of warning time. The people on the coast of Thailand got about 40 min to run for their lives. Punishment came to those who failed to take advantage of the lag time. The death toll in of Sri Lanka exceeded 40,000 despite the lag time of more than 2 h between the occurrence of the earthquake and the attack of the tsunami on the Sri Lanka coast. This was the reason that even after as many as 8 h of warning; nearly 300 people got killed in Somalia. Kenya was alert to the threat which is why timely escape reduced the death toll in Kenya to just 1. Indonesia got just 15 min with wave heights of about 20 m throwing a new challenge to the first responders.

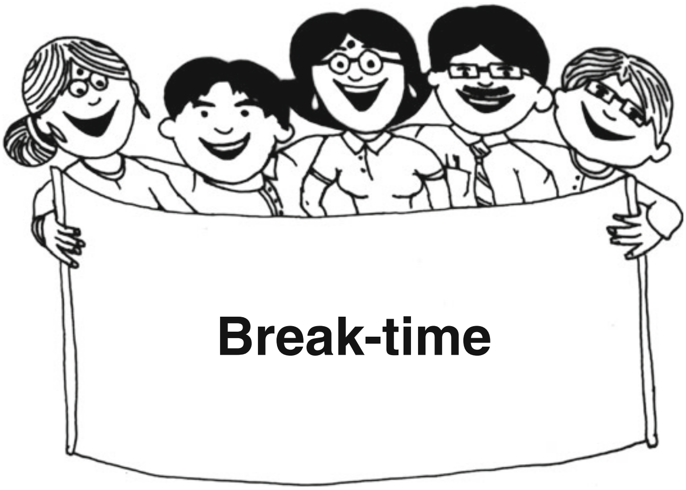
The positive side of the story is that within 3 min and 30 s of the earthquake, the USGS National Earthquake Information Center (NEIC) in Golden, Colorado and the NOAA tsunami warning centers in Hawaii and Alaska received the earthquake information automatically and the tsunami has now given a huge impulse to the research on tsunami early warning.

The other extraordinary gain is that our tolerance levels and capacity to absorb pain has gone up. We now understand better the disconnect between the pain and statistics. People from outside the region felt the pain of the tsunami in terms of the statistics—230,000 people killed; over 17 lakh people rendered homeless; 100,000 houses destroyed, with losses amounting to US $9.9 billion. Those affected by the tsunami within the region felt its impact in terms of the suffering beyond words! The global concern disappeared when some other episode in some other part of the globe hit the headlines. The pain of the victim will continue to be felt for generations.

Stealing Life from the Jaws of Death

Amidst the ghastly scenarios of death and destruction, some people were able to steal lives from the jaws of death. We heard the remarkable story of a 10-year-old school girl, who saved many lives because of her elementary knowledge of tsunami and her alert mind. While she was holidaying with her family at the Maikhao Beach in Thailand, she saw the sudden receding of the seawater leaving behind an empty coast. From her geography teacher in a British School, she had learnt that receding sea was a sign of an incoming tsunami.

Similarly, people of the Onge tribe in the Andaman Island knew from their forefathers that sea waves following major earthquakes can invade the coastline and so they moved uphill and saved their lives.



Break-time question 3: Tsunami waves are usually missed out in the open deep sea because of their low wave heights and large wave lengths. Do you know who were the first to demonstrate that even then tsunami waves in open deep sea can be detected and how?

Answer to break-time answer 3

The research team of National Oceanic and Atmospheric Administration (NOAA), USA, is credited to be the first to connect the roughness of the sea surface texture with tsunami waves by reading the changes in the sea surface texture in the open sea through Satellite borne radars. It is reported that tsunami wave motion stirs up and darken the oceanic surface waters forming “a long shadow like strip parallel to the wave and proportional to the strength of the tsunami”.

Reference. Godin et al. (2009), pp. 1135–1147.

Landslides

Terminology

The term *landslide* is made of two English words, namely, *land* and *slide* and it literally means sliding of relatively unstable parts of a slopemass over a relatively stable part, over a well-defined slip (sliding) surface. The above definition of the term *landslide* is too restrictive in the sense that, in the real world, landslides of different types do occur in a bewildering variety of geoclimatic settings and geological formations, not necessarily by sliding. Their causative factors and mechanisms of occurrences may widely vary from one another and so do their speeds. Interestingly the speeds of some types of landslides, for example volcanic flow, can be so high that even the unbeatable Usain Bolt may not be able to escape its wrath. On the other hand, there could be slides so slow moving that even a snail would be a winner and one would need sophisticated instrumentation to detect their creeping movements. The term *landslides* should therefore be regarded as a generic term embracing all kinds of slope failures and mass movements.

More than half century ago, Karl Terzaghi, the Father of Soil Mechanics, defined landslide as “rapid displacement of a mass of rock, residual soil or sediment adjoining a slope,” in which the center of gravity of the moving mass advances in a downward and outward direction, Fig. 3.24. Further, he suggested the term creep to define very slow slope movements. The definition of the term *landslide* was further enriched, especially by Hutchinson and Varnes. It now stands for all varieties of mass movements on slopes, including some common types such as rockfalls, topple, and debris flows even when they may not involve *sliding*.

Basic Concept of Slope Instability and Landsliding

For understanding the basic concept of landsliding, it is useful to imagine a person who has just stepped on the skin of a banana. His weight will create an unfavorable lateral force making him slip over the smooth face of the banana skin even if the ground were to be flat. He may slip, roll, and fall even more severely, if the banana skin were to be resting on a slope. This situation is somewhat similar to the one observed when a child accidentally steps on a smooth incline in a public park, Fig. 3.25. If the incline is not smooth but rough, its high frictional resistance may prevent sliding. The very same thing happens in nature. There are forces which provoke landsliding on mountainous slopes and there are forces which resist landsliding. A landslide eventually occurs when the forces provoking sliding collectively overpower the forces preventing sliding, making the slopemass move downhill.

Causative Factors

Let us understand more clearly the forces which cause landsliding and the forces which resist or prevent landsliding by considering the example of the famous tug of war that took place between the devils and the angels in the Hindu mythology, Fig. 3.26.

Just as devils won the war whenever they could overpower the angels, forces destabilizing slopes also win causing a landslide when the forces resisting landsliding get overpowered. In the context of landslides, gravitational force, earthquake force, heavy rainfall, unfavorable slope geology, adverse topography, deforestation, bad slope drainage, urbanization, and improper land use are always on the side of the devil instigating slope failure. Favorable geology, structurally strong rock masses, afforestation, good slope drainage, efficient landuse, and good slope management are always on the side of angels.

Those who live in the fragile mountainous areas of our planet Earth are very familiar with landslides as a common type of geohazard. Immature, mountain slopes continuously undergo changes due to slope degradation, slope erosion, and landsliding over the geological time scale. Forces of gravity, seismicity, and water forces tend to sculptor the slopemass and provoke landsliding. The strength of rocks and soils of which the slopes are composed and improved slope surface characteristics due to vegetation tend to prevent sliding.

Causative factors in a given case could be many and should be studied on a case to case basis. Urbanization involving construction of buildings and roads disturbs the equilibrium of a slope, besides altering the pattern of surface and subsurface drainage. Road cuttings made at the bottom of a problematic slope and loading of its head region add to the forces of sliding. The poor drainage condition also promotes slope failure by reducing the shear strength of the rock or soil mass at the surface of sliding. A typical landslide on a noncircular slip surface is shown in Fig. 3.27. The shape of slip surface could be planar, circular, noncircular, or complex.

From Landslide Hazards to Disasters

Every time a landslide occurs, the failed slope comes to a new balance, as the natural processes of erosion, degradation, and landsliding continues on forever. In this way, the landslides by themselves are no more than nature's safety valves in the process of slope evolution. Only when landsliding begin to harm mankind that

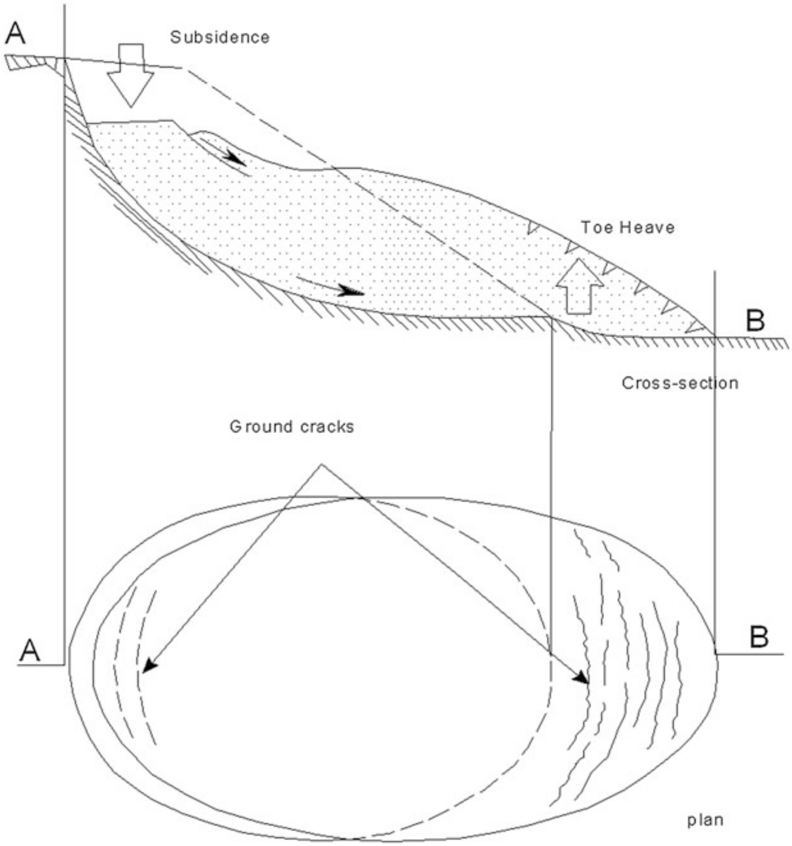


Fig. 3.24 Morphology of a typical landslide depicting the three of its essential elements namely **a** subsidence at the head of the slide, **b** heave at the toe of the slide, and **c** distortion of the landslide mass. In a landslide, the slope mass tends to move in the downward and outward direction

Fig. 3.25 Two common examples of sliding

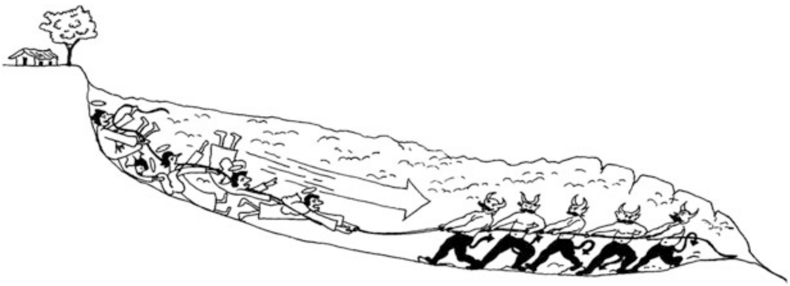


Fig. 3.26 The occurrence of a landslide can be explained in terms of the tug of war between devils and angels in the Hindu mythology (see the text). Landslides occur when the *devils* win

Fig. 3.27 Construction of buildings in hilly areas generally alters the behavior of slopes on which they are built. The cuttings made to create space for the building construction may destabilize slope to the point of failure. Urbanization on slopes is known to impair natural drainage thereby making the slopes unsafe. Engineers take all these factors into consideration in slope engineering

it becomes a cause of concern. Remember, if the mountains of the world were to stop decaying by nature's design, how shall we have fertile plains for agriculture?

Growing levels of human violence against the mountain ecosystem have accelerated the processes of slope degradation so much so that landslides have now begun to kill people, destroy human settlements, and communication systems, besides reversing the very process of development. The landslides hazards are therefore taking the form of landslide disasters. These disasters are mostly avoidable by timely preventive action and holistic engineering intervention.

Major Types of Landslides

Broadly speaking, common types of landslides are (a) soil and rockfalls (b) landslides and other mass movements on well-defined (discrete) failure surfaces (c) mass movements such as flows and avalanches on ill-defined boundary shears,

(d) complex landslides, and (e) landslides due to bursting of Glacial Lakes and Embankment Dams.

It may not be a good idea to classify landslides without scientific investigation merely on the basis of the impressions of a site visit which may be deceptive. A given landslide looks differently at different times. In the fair weather, it may deceptively look stable and innocent. In the rainy season, the very same landslide may give you the run of your life. In the real-life situations, in the first encounters, all types of mass movements should be designated as landslides. Upon completion of the geotechnical investigation, its classification will naturally follow.

Soil and Rockfalls

Most of us have seen falling rocks while traveling on hill roads in landslide prone areas. A very simplistic picture of rockfall is shown in Fig. 3.28. In real situations, detached pieces of falling rocks may also slide, bounce, roll, and spin while hurtling down a slope, Fig. 3.29. In a rockfall infested areas, one can easily find precariously perched boulders and rock masses waiting to fall. If timely remedial measures are not taken to arrest a rockfall, it may hit all that come on its way, kill people, and destroy infrastructure, Fig. 3.30. One spectacular example is of the Lyangahawela Bridge in Sri Lanka which was destroyed for the second time by the rockfalls within a span of about 40 years, Fig. 3.31. We now design bridges to withstand the impact of rockfalls. Implications of unplanned quarrying (Fig. 3.32) and absence of legal controls (Fig. 3.33) are hurtful.

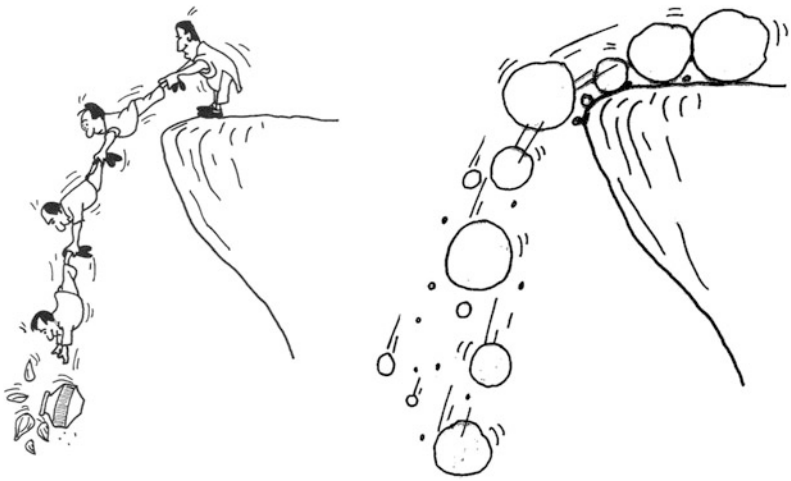


Fig. 3.28 Just as people are seen to fall off a slope one after the other with very loose coupling between them, precariously perched rock fragments and boulders too begin to fall in a continuous stream. Rockfall is the name given to such a mass movement

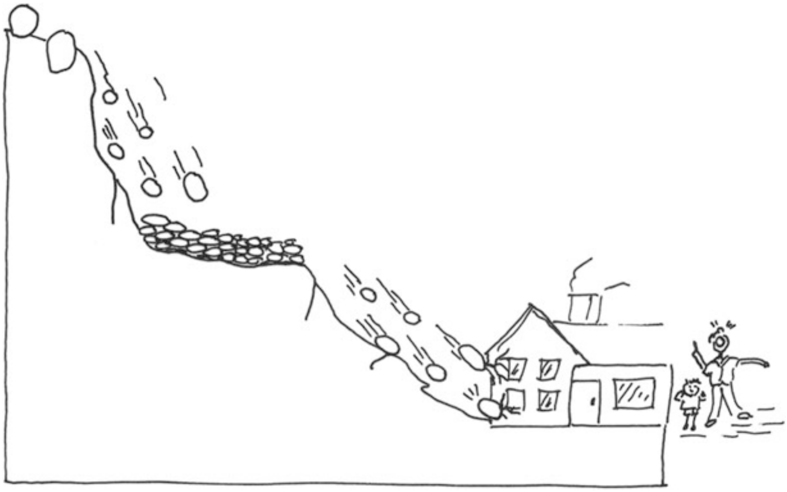


Fig. 3.29 The figure shows a rockfall threatening the safety of the built environment including the houses downstream

Fig. 3.30 Threat of falling rocks (rockfall) on hill roads is quite common. There are a number of ways to arrest rockfalls. Early warning systems are additionally used to prevent rockfall accidents

Fig. 3.31 Lyangahawela Bridge in Sri Lanka which was destroyed for the second time by rockfall within a span of about 40 years. Bridges in the rockfall prone areas should be designed to absorb the impact of falling rocks (*Artist* Sunil Fernando)

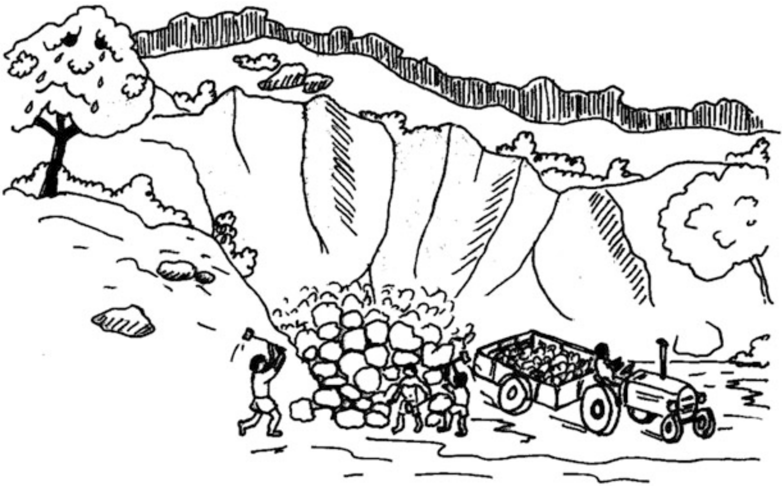


Fig. 3.32 Unplanned and nonengineered quarrying and mining operations are responsible for alarming levels of environmental degradation. Besides halting the process of degradation, workmen engaged in the quarrying operations need protection from rockfall hazards

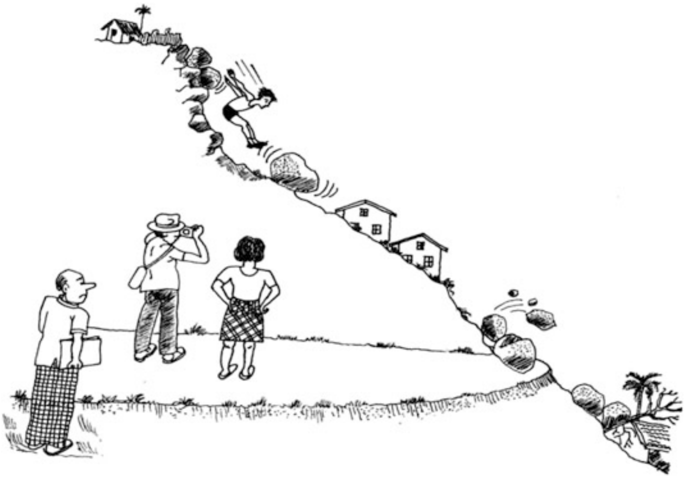


Fig. 3.33 Look dear, we can now argue that the boy is the cause of this rockfall and not the quarrying operation. I have captured this whole story in the video and with this clinching evidence; our attorney should be able to defend our illegal quarrying in the court of law

Landslides on Well-Defined (Discrete) Failure Surfaces

A typical landslide which takes place along a well-defined slip surface often leaves behind its visually recognizable signatures (trail) in the form of slide boundaries, Fig. 3.34. The simplest access to such signatures is provided by a planar slide, Figs. 3.35, 3.36, and 3.37. Such slides are the easiest to investigate, analyze, and control.

Many slope failures involve a component of rotation. In such failures also we see the signatures of the slide in the form of back-tilting of trees in the head region and forward–tilting of trees in the toe region, Fig. 3.38. In fact, such observations are often used as indicators of early warning. It, however, requires specialists to interpret the slope features, because in many types of slides, such as the one shown in Fig. 3.39, the trees may still remain vertical despite the landslide. In this category, we must also recognize future landslides on slopes which may look harmless today, Fig. 3.40 but could eventually develop because of the progressive slope failure over the passage of time.

Mass Movements on Unrecognizable Boundary Shears

Geological materials, when water saturated, acquire mobility to flow along the steepest slope gradient instead of sliding. On long continuous slopes, such flows may acquire a very high speed which is why they are popularly called rapid motion landslides. The term soilflow, earthflow, mudflow, earthslide, mudslide, debris flow, debris slide, and debris avalanche are all interchangeably used in different parts of the world to classify the mass movements of more or less the same kind with some variations. Without detailed scientific investigations, it is not possible to make a fine distinction between such mass movents.

An excellent example of a slide on ill-defined sliding surface is of the earthflow of 8 October 1993 which occurred at Helauda in the district of Ratnapura in Sri Lanka, Fig. 3.41. It turned into a major disaster killing 31 people living at the bottom of the slope, Fig. 3.42. Flows are often recognized by the accumulation of slopemass at their lower end in the form of tongues, Figs. 3.43 and 3.44.

Fig. 3.34 The picture shows a text book example of a landslide with well-defined (discrete) landslide boundaries like of which are seldom exposed in nature. In many cases slide boundaries are short-lived. The other point to notice is the shape of the slide. In this case, it is elongate in shape with its length far exceeding its width. In lobate failures, the width and the length of a slide are not very different

Fig. 3.35 Block and slab slides which occur on discrete boundary shears are known as planar landslides. The point to observe is the unfavorable slope geology which promotes planar slides

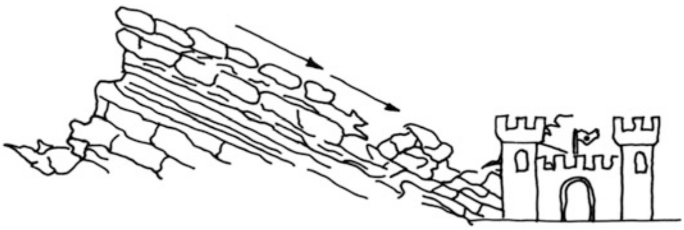


Fig. 3.36 The figure shows a landslide on a planar slip surface. The geology that promotes such sliding can be easily seen in road-side cuttings. In all the above cases, geological details play a major role in defining the slide surface

Fig. 3.37 The picture shows a slab slide on a hill road in Yemen. Parking of car right at the site and work at the site without helmets are bad practices which must be avoided

Examples of Landslides on Well-Defined Sliding Surfaces

Fig. 3.38 The figure shows a rotational type of landslide with a well-defined slip surface on which the slide had occurred. In such types of landslides, the trees in the head region of the slide are seen to tilt backwards and those at the slope bottom show a forward tilting

Fig. 3.39 The figure shows successive deep-seated slides with well-defined boundaries but the mechanism is such that trees do not show tilting

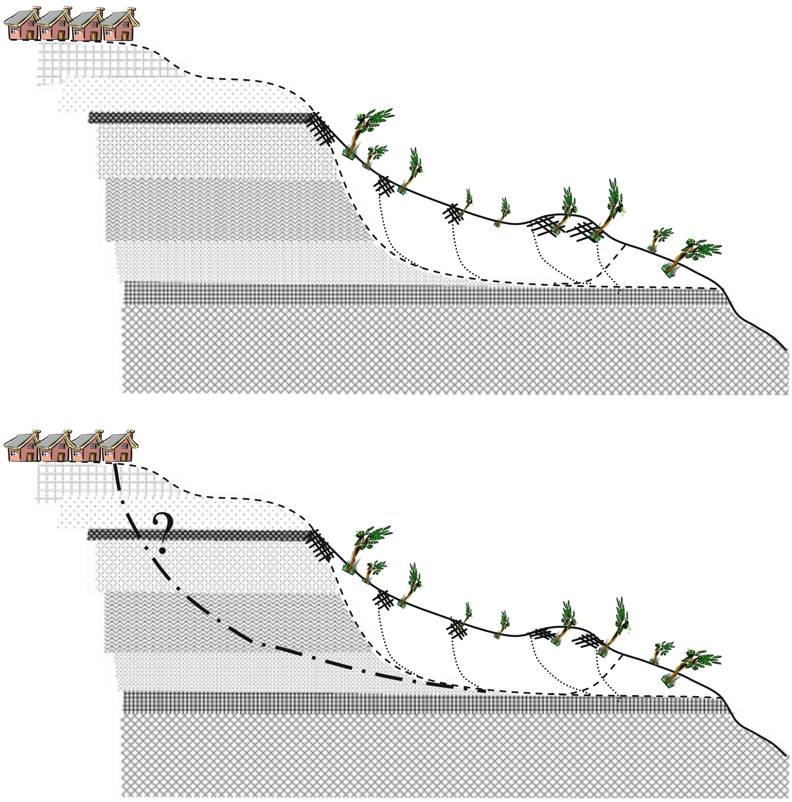


Fig. 3.40 The set of two figures show retrogressive (backward growing) landslides. Such landslides usually begin with a small slip in the toe region of the slope and slowly grows backwards becoming bigger and bigger. Eventually, the successive slope failures join together to trigger a massive landslide. The first landslip in the region of lower slopes being harmless fails to capture imagination but the enlarged landslide poses a real threat to buildings on the top and at the bottom of the slope

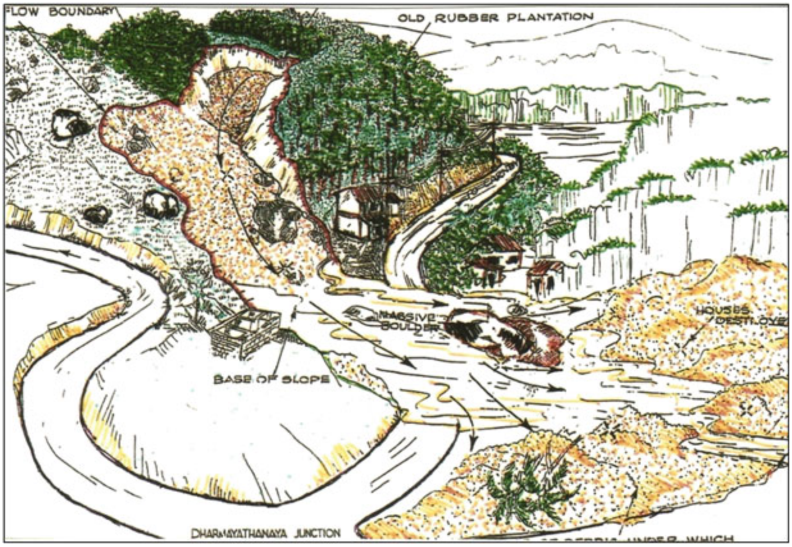


Fig. 3.41 An artist's view of the deadly earthflow at Helauda in the district of Ratnapura in Sri Lanka

Fig. 3.42 The picture shows the earthflow at Helauda. Heaps of earth created by the earthflow were so tall (compare the heaps with the height of men at work) and the exact location of those buried was so uncertain that lives could not be saved. Modern technology enables us to speedily locate the buried and rescue them

Fig. 3.43 Coastal mudslides in stiff, fissured clay slopes of the Herne Bay in the United Kingdom have many unique features. One such feature is the formation of a mudslide tongue, as shown. It encroaches into the sea and gets eventually removed by the tidal waves. The process is repeated cyclically but it is not life threatening

Fig. 3.44 The toe end (tongue) of the debris flow at Sonapur in the State of Meghalaya in India is seen to overrun the river bank, narrowing the river passage. Such situations are prone to formation of a landslide dam due to temporary blockade of the river by the advancing landslide debris

A Notable Example of a Ghastly Rock Avalanche Tragedy

Malpa rock avalanche of the State of Uttarakhand in India is a rare, unique, and a speaking case record of a rapid motion landslide of formidable consequence. It struck the hamlets of village Malpa[4] on the night between 17 and 18 August 1998. On that fateful night, a huge mass of rock got detached from the head region of the parent rock; it then broke into myriad of pieces, and hurtled down the slopes all under the watch of an eyewitness. The rock avalanche so generated killed 210 people including 60 pilgrims. In a sense, it wiped out the entire village of Malpa, leaving behind stunned survivors, ugly scars on the mountain slopes, heaps of debris, remnants of the township, and a few dogs! The pictures of Malpa village taken before and after the rock avalanche tragedy tell the tale, Figs. 3.45 and 3.46.

For years, the village of Malpa was the base camp for the pilgrims to Mansarovar and Mount Kailash in China. It was traditionally inhabited by tribal people, engaged for generations on trade with Tibet. With the onset of the tourist season and opening of the pilgrimage route, the Malpa village began to bustle with human activity. Public Works Department, Indo-Tibetan Border Police, and the local tribal people had also put-up their huts in Malpa to feed the growing seasonal demand. A day before the landslide tragedy, all guest houses and huts got fully occupied leaving no room even for the officials of Border Road Organization on field duty. The eyewitness[5] who happen to be one of Border Roads official failed to get accommodation in the guest house and had no other option but to spend the night in the only available hut at a higher elevation on the slopes. For him, this forced arrangement turned out to be a savior, and a vantage point from where he could see the unfolding of the drama of the rock avalanche from its origin to the end. It now looks by hindsight as though he was chosen by the providence to witness the specter and tell the tale!

It is said that every night has a dawn and when the dawn comes it exposes the secrets of the night. The lush green hill slopes surrounding the Malpa village kept the rock avalanche as a secret for most part of the night of 17 August 1998 but the very next morning, it narrated the whole story through the altered landscape littered with heaps of debris more than 15 m tall. By reconstructing the sequence of events, it also became clear that rock fragments as big as 5 m had traveled down the slopes with speeds in the range 10–30 m/s.

Some Exception Evidences

Natural events often leave signatures and evidences behind but we generally fail to capture these because of the delay in investigations. Malpa rock avalanche was inspected by several investigation teams more for loss assessment than for geotechnical studies. Even then it became clear from the indelible signature of the

[4] It is situated on the right bank of river Kali, in the district of Pithoragarh of the Kumaon Himalaya in India bordering Nepal.

[5] There are only ten survivors of the Malpa tragedy including the eyewitness, an officer of the Border Roads Organization of the Government of India.

Fig. 3.45 A panoramic view of the Malpa village before it was struck by the rock avalanche on 17 August 1998

Fig. 3.46 The above set of pictures shows the scenarios *before* and *after* the Malpa rock avalanche tragedy which struck the village of Malpa on the fateful night between the 17 and 18 August 1998. The avalanche acquired speed as high as 30 m/s, left behind a heap of debris as tall as 15 m at the foot of the slopes and killed 210 people

rock avalanche that a huge rock mass had got detached in the head region of the slopes breaking into myriad of pieces. These flying rock fragments were seen in the skies clashing with one another. To the distant eyewitness all this looked like dancing bright flashing lights on the upper mountain slopes. Slope violence was so severe that thunderous noise was heard at long distances. The story narrated by the eyewitness at Malpa is similar to the eyewitness account of the catastrophic Nanjiang rockslide of the Northern Sichuan, China (Wang et al. 1996). In both the cases, the speeds of the slides were so high that the flying rocks rammed into one another, creating continuous thunderous noise, and flash of light sparks visible from long distances.

The rapidly moving rock avalanche created a dust storm. The evidence of this dust storm would have been lost but for the veil of brown dust carpet seen on the lush green slopes. The fine particles of the rock avalanche were picked and transported by the duststorm up to about 500 m in the windward direction.

One standard question often asked after such tragedies is that whether the disaster was avoidable? Some experts including the author believe that indeed it was avoidable. In this case, the clear early warning signs of the rock avalanche were ignored when the people of Malpa failed to take note of the thunderous sound and falling of boulders seen long before the tragedy on the 15 August.

The Snow Avalanche that Produced the First Woman Everester

Her first-hand account of the encounter is given below:

> I was at 24,000 feet and this happened at around 10 pm or midnight, when I was sounds asleep. I was hit at the back of my head by something very hard, and simultaneously, I heard a very loud explosion. I thought it might be a burst oxygen cylinder we had kept outside our tent, but suddenly I felt that I'm crushed under a very heavy load, so then I realized it's a very big avalanche, and I was sharing my tent. I was just thinking of death… I'm going to die; I'm going to die. Overcoming that life and death situation, the person who was sharing my tent came out, and he luckily got a Swiss knife in his pocket. So he could tear open the tent. And first he came out and he dug me out; he removed the ice melts on the top of my body and that time the outside people, everybody was crying and all of them were very panicked. Some had broken ribs, leg fracture, or head injury; some people were vomiting blood; coming out of a very painful scene. So we spent that night there, then we informed our leader and he sent a rescue team. The next day, early morning at 05:00, that rescue team reached our camp, and then we carried that injured person down to 22,000 feet. Then our leader here had an interview with everybody: So what you want to do? All the members, some of them were injured, but some were in a state of shock and they decided to go back and then he asked me, so I said "Since I have overcome this, I am alive, now after this life and death situation, I must try once again. And that decision was the turning point of my success story.[6]

It is no longer news to us that indeed she made it to the top of the world and thus became the first women to climb the mighty Everest! For those who yet to have a go at mountaineering, high altitude trekking and facing an avalanche may lead to high pulse rate, breathlessness, loss of appetite, and skin burns, Fig. 3.47.

[6] *Source* Excerpt from an interview of Bachendri Pal, the first Indian woman to climb Mount Everest with Holly placed on the net by Adventure Divas, India.

Fig. 3.47 Snow avalanches cause high pulse rate, breathlessness, loss of appetite, and skin burns. The first responders should necessarily be trained in dealing with the problems of high altitude and cold climate. They should familiarize themselves with the highly developed tools and techniques of rescue and relief distribution

Landslide Classification Based on Landslide Speed

It is both common and convenient to consider the speeds of landslides in relation to the types of landslides, Fig. 3.48. The speeds of movement of different types of slides are shown in Fig. 3.49.

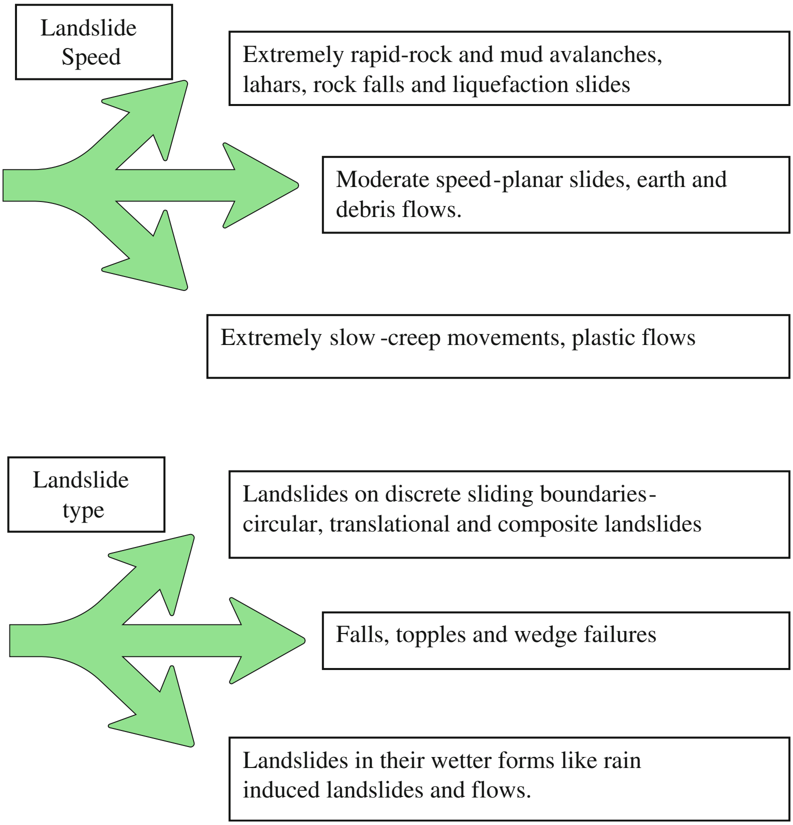


Fig. 3.48 Two important attributes of landslide classification

How Fast Different Types of Landslides Move?

See Fig. 3.49 for details.

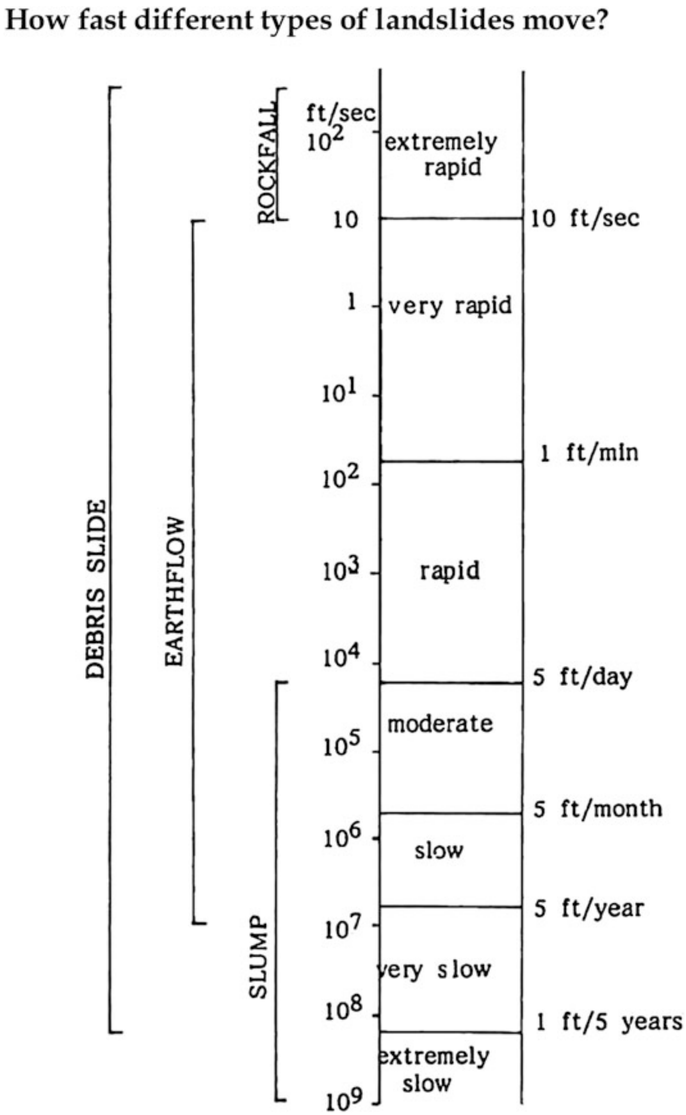


Fig. 3.49 Volcanic mudflows (lahars), glacial lake outburst floods, and rain-induced mass movements are examples of *rapid motion landslides*. The slope movement at imperceptible rates over long periods of time, under the force of gravity is called creep

Some Vital Facts You Need to Know About Landslides

- No two landslides are identical even in the neighborhood. Unlike man-made materials like steel and concrete, geological materials of which the slopes are made show a history, complexity, and time-dependent behavior. Variations in landslide behavior may also occur because of the variability of the forces causing landslides, especially urbanization, seismicity, and rainfall.
- Human violence against our mountain ecosystem is mainly responsible for a great majority of the landslides. Once the slope becomes weak and frail, the triggering factors like rainfall and seismicity begin to dominate. It should be understood that rainfall and seismicity have coexisted with all slopes at all times throughout their geological history and their share of blame in assessment of a landslide must be analyzed in that context.
- It is wrong to say that steeper slopes are always more unstable in comparison with relatively flatter slopes. In fact, flatter slopes can be more dangerous than the steeper ones with unfavorable geology and poor slope drainage. On the other hand, well-drained steep slopes with robust geology can stand even vertical for centuries.
- It is false notion that slopes of great heights are always more unsafe than slopes of relatively smaller heights. Factors such as geomorphology, geology, age of the geological deposits and their stress–strain behavior, slope hydrogeology, slope seismicity, and anthropogenic play their respective roles.
- Two slopes of the same height and the same slope angle, when covered with similar grass may have more or less identical physical appearances but their respective behavior patterns over a certain length of time may be entirely different. For example, a cutting and an embankment of identical geometry may look alike but will behave differently because of the basic differences in their histories of construction.
- A road-side cutting in stiff materials is known to progressively weaken and become less and less safe because of what is called *progressive failure* in soil mechanics. The term progressive failure simply means time-dependent weakening of the stiff geological materials such as clays.
- Many landslides, especially in materials like shale and stiff fissured clays, take place on highly polished sliding surfaces. Such polished sliding surfaces are created because of large landslide displacements over a length of time. Some sliding surfaces may even acquire the gloss of a sunmica. Such polished slip surfaces when detected during a site investigation throws light on the history of landsliding in the area.
- “There are many evidences that landslides are not sudden phenomena. Almost in all cases a period of slow movements precede them; their duration can fluctuate over a wide range for several days up to many years. These

movements get accelerated before slope failure. Sometimes those movements continue after the failure too."[7]

- "If a landslide comes as a surprise to eye witnesses, it would be more accurate to say that the observers failed to detect the phenomena which preceded the slide,"[8] Fig. 3.50.
- "Landslides constitute a continuous series of events that rarely can be attributed to one definite cause. Slope stability is a dynamic equilibrium problem and an attempt to determine the cause of a landslide is nearly always futile, because there are invariably a number of contributory factors."[9]

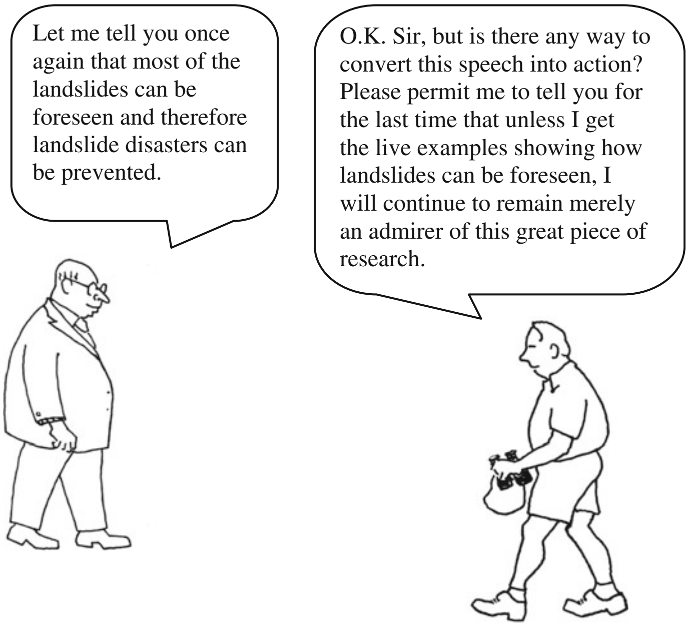
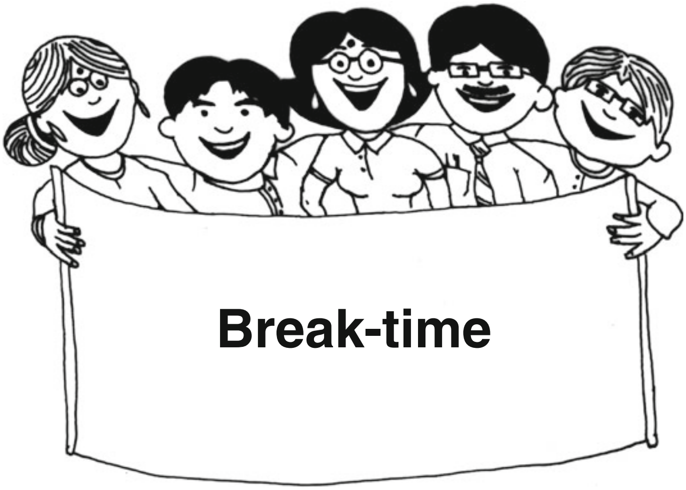


Fig. 3.50 It is true that landslide disasters are avoidable because most of the landslides could be foreseen through a well-structured program of slope investigation, instrumentation, monitoring, and preventive action. Techniques of slope instrumentation and real, time monitoring are sufficiently well developed to make early warning against landslides possible. Why things are not happening is because of lack of focus, nonserious site investigations, absence of holistic approach, and determined team work

[7] See Popescue (1984), p. 94.

[8] See Terzaghi (1950), pp. 83–123.

[9] See Popescue (1984), p. 86.



Break-time question 4: Why a road-side cutting which had remained safe for many years after its construction is seen to suddenly fail after a few months or years? How do we explain this scientifically?

Your Break - time question explained

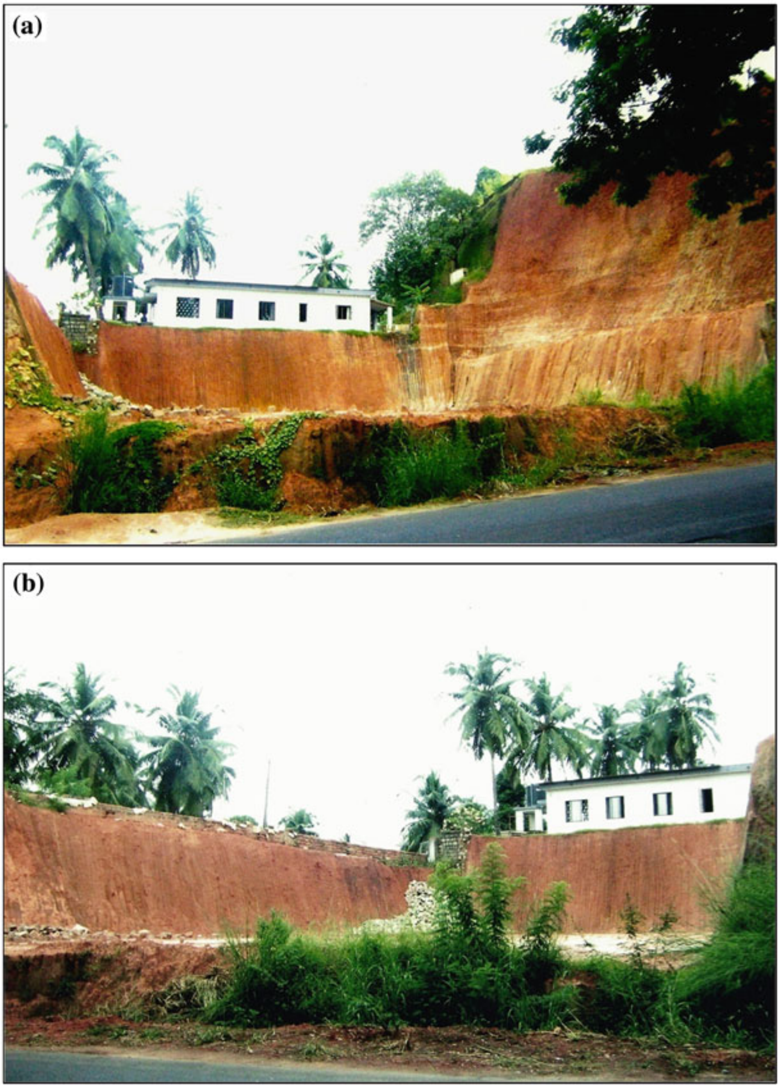


Fig. 3.51 **a** and **b** The two pictures of a high, unsupported cutting in residual soil formed by in-place weathering of basaltic rocks is from the city of Mangalore in the State of Karnataka in India. The common observation that fairly deep cuttings can stand vertical without outer support encourages building contractors to make such cuttings when needed, even very close to the existing buildings, as shown above. They ignore the fact that a cutting which is safe today may fail tomorrow or after a few years. Why should a cutting which is safe today should fail subsequently? It is the question we must answer. (*Photos* Ashok Mendonca)

Answer to Break-time Question 4

Cuttings in stiff geological materials are the safest in terms of their margins of safety at the end of their constructions. Their margins of safety, however, progressively reduce with the passage of time ultimately leading to slope failures and landslides. The reason is the following:

When we make a cutting in soils and rocks of a given geology, we excavate and remove the earthmass to make space for the cutting. The removal of the earthmass from a slope comes as a relief of load (stress) to the slope just the same way as a loaded spring system will feel relieved when a part of the load is removed. The slope tries to rebound upon removal of the earthmass. This happens not suddenly, but in a time-dependent manner because the stiff geological materials behave in keeping with the history of their formation. As the slope rebounds progressively, it takes moisture from the water vapor in the atmosphere. The intake of moisture softens the slopemass due to the decrease of the shear strength. The cutting mass becomes weaker and therefore becomes less safe. This is the reason that engineers relate the safety of the cuttings they design with the design life of the cutting. An example of bad slope engineering is shown in Fig. 3.52.

Fig. 3.52 A cutting in the residual soil slope at Ootacamund in State of Tamil Nadu India, as shown in the picture, failed because of the combined effect of progressive weakening with the passage of time, poor maintenance, and inadequacy of drainage in the rainy season

Lightning and Thunderstorms

> Thunder is good, thunder is impressive, but it is the lightning that does the work.
>
> Mark Twain

Lightning

Lightning is one of the most dramatic sharp shooters camouflaged by the cumulonimbus clouds in the skies. It is a living experience hard to imagine and even harder to understand. With all the science and technology at our command, can we make a lightning bolt travel at 14,000 mph and deliver 300,000 amperes of electricity to the ground within a few milliseconds? Do we have even the slightest feel of the levels of heat that raises the ambient air temperature to whopping five times higher than the temperature at the surface of the Sun? Yes, we are talking about temperature close to 30,000 °C!

Lightning fascinated Benjamin Franklin and caught his imagination. He succeeded in drawing electricity from a rain cloud using a key tied to a kite and was first to demonstrate that rain clouds are electrically charged. Richman became the first to prove that electric charge of the clouds leads to lightning.

We are most familiar with the cloud-to-ground lightning because of its direct impact on us. Lightning is known to occur when the lower parts of negatively charged clouds strike chord with the earth, and deliver the electrical charge. It is not always that lightning carries negative charge. It does carry positive charge, especially during the fading phase of the thunderstorms. Lightning can also occur within a cloud between the centers of opposite charges. Intercloud lightning mechanism is quite similar. The possibilities of lightning between and *within* clouds are shown in Figs. 3.53 and 3.54.

It is worthy of note that lightning seldom strikes the Earth if clouds are above 10-km height. Most lightning flashes are seen between heights of 4–6 km.

Thunderstorms

Lightning heats up the atmospheric air. As the air gets heated up; it rapidly expands and generates expansion waves. Exactly the opposite of this happens during the discharge phase of lightning. In other words, lightning discharge causes rapid contraction and generates contraction waves. The intercourse of rapidly expanding and contracting shock waves produces thunder. Any storm which is accompanied by thunderous sound is therefore called a thunderstorm. "*Thunderstorms are* *atmosphere's most familiar dramatic events. Its destructive off-springs are the hailstorms, lightning, high winds, heavy rains, and the most violent of all are tornadoes.*"[10]

Lightning and Thunderstorms in Action

Where there is no lightning, there are no thunderstorms. If statistics are an indicator, lightning strikes over 100 locations every second, in different parts of the world. In about the same time 1,800 thunderstorms sweep our planet.

It is often asked: Why do we see lightning first and hear the sound of the thunder afterward? This is so because the light rays travel very fast (186,000 miles per second) and reach us almost instantly, whereas the sound of thunder trails behind traveling at a much slower speed of 0.2114 miles/s, and takes some time to reach us.

How far is the lightning from us comes as the next question? We can find the distance to lightning by clocking the interval of time between the flash of lightning and the sound of the thunder. For example, if the interval of time clocked between the two is 10 s, lightning is merely (0.2114×10) about 2 miles away and, boy, that is really too close! If the interval of time is 30 s, lightning is about 6 miles away and we have a reasonable chance to escape by promptly rushing indoors. Not many of us realize that lightning can also occur in snowstorms, dust storms, and in the volcanic clouds.

[10] Quotation from one of the speeches of G. S. Mandal.

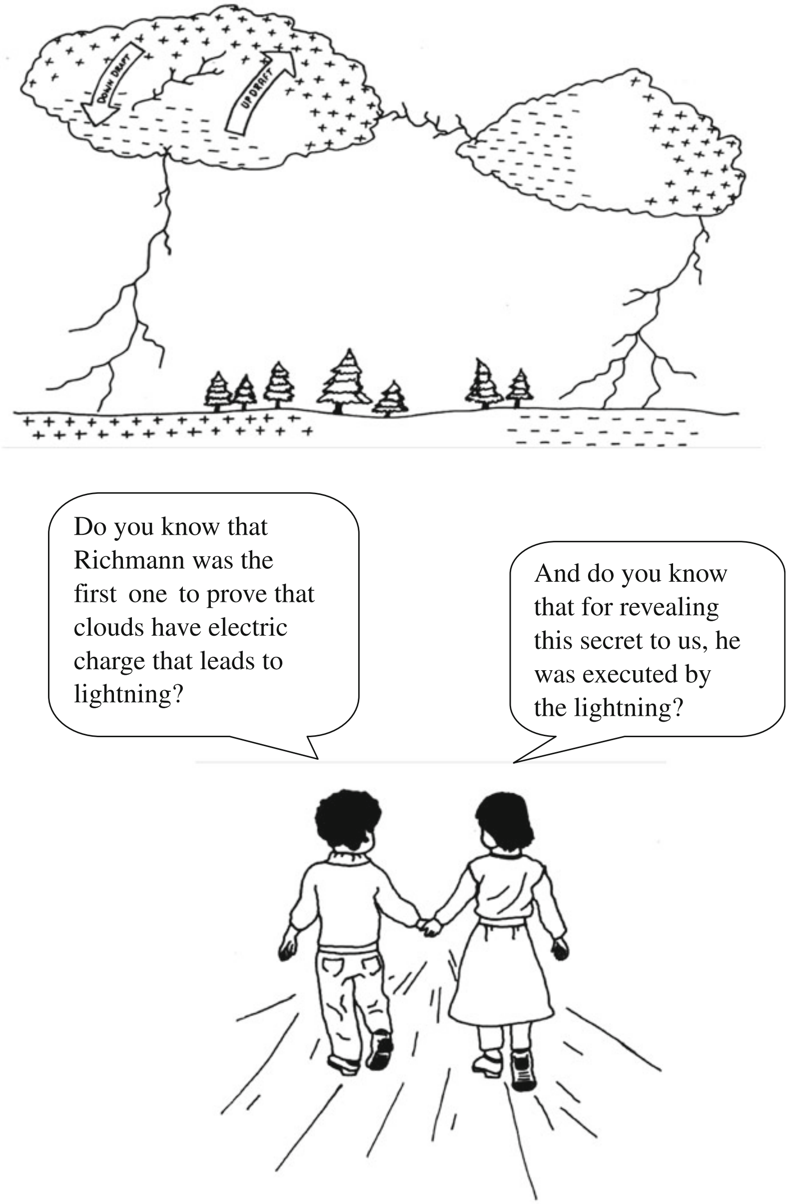
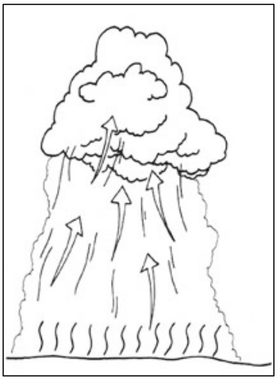
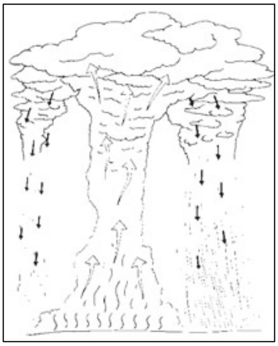


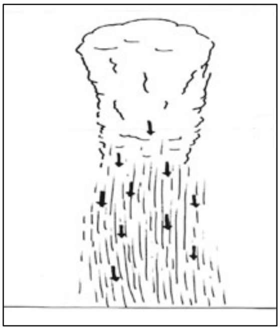
Fig. 3.53 Lightning generally occurs from cloud-to-ground but it could also occur *between* and *within* clouds



Stage1: When the solar radiation leads to rise of temperature of the ocean surface above 35 °C, updrafts of warm humid air creates cumulus clouds which have a flat base and a rounded fluffy top. As these clouds rise to heights between 2.5 km and 6 km above the ground level, cooling occurs and moisture condenses in the clouds. The rise of the clouds continues so long as the updraft is warmer than the surrounding air. The clouds so produced are also called thunderclouds or altocumulus clouds.



Stage 2: This is the stage of maturity which takes clouds (cirrocumulus) to heights between 6 km–12 km. As the updrafts begin to lose steam, they can no longer rise further. Interestingly at this stage, updrafts and downdrafts co-exist. In the process, cumulonimbus incus clouds are born. The increasing size of water droplets and their freezing make clouds heavier and the rainfall occurs.



Stage 3: In this stage of dissipation, the downward drafts battle the upward drafts and dominate, causing huge internal disturbance creating an ideal breeding ground for thunderstorms, strong winds, and lightning. The dissipation of energy due to internal atmospheric disturbance makes clouds to shrink and release water in the form of cloud bursts and rain. Occasionally tornadoes are formed.

Fig. 3.54 Stages of formation of a thunderstorm

Tornadoes

The word *tornado* is of Spanish origin, coming as it does from the word *tornare* meaning *turn*. It is considered to be the most violent of winds with speed brow-beating the hurricanes of category 5, often shooting up to 750 km/h. The highest tornado speed of 460 km/h was measured in April 1991 near Red Rock, Oklahoma. Since tornadoes can spin tightly with awesome speed, the energy within a single tornado can equal a 20-kt atomic bomb. Surely it could be more violent than a cyclone because it concentrates its energy over a relatively narrow belt of the landmass, Fig. 3.55. The diameter of disturbance associated with a tornado is highly variable and may range from a few meters to more than a kilometer.

Sometimes tornadoes do odd things. A tornado once sucked up a pond full of frogs and rained them down on a nearby town. Another tornado struck a house and carried a five-hundred-pound piano twelve hundred feet through the air.

Source Tornadoes by Seymour Simon (1999).

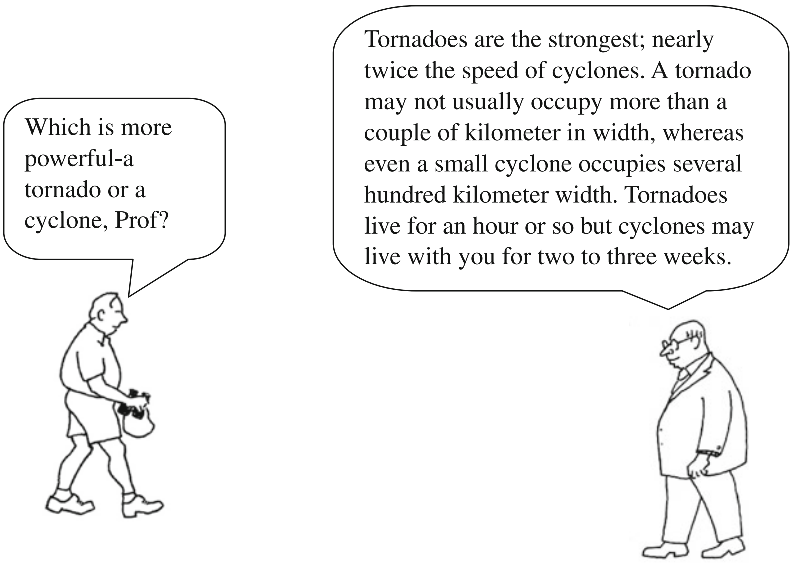


Fig. 3.55 Which is bigger—a tornadoes or a cyclone?

Dust Storms

The term *dust storm* implies fiery winds loaded with clouds of dust. At times, the wind force is so high that, regardless of the load of the dust, the clouds may scale heights on the order of 300 m and reach distances of tens of kilometers. In most cases, however, wind prefers to carry cohesionless less dust particles usually of the size of sand grains resulting into what we call sandstorms. Higher the sand content in a storm, lesser is its carrying capacity as also the power to climb high or travel farther. Desertification and land degradation are often responsible for dust storms, Fig. 3.56

Threats from dust storms come from the hard hitting winds and extremely poor visibility. It is therefore common to classify dust storms in terms of these two parameters.

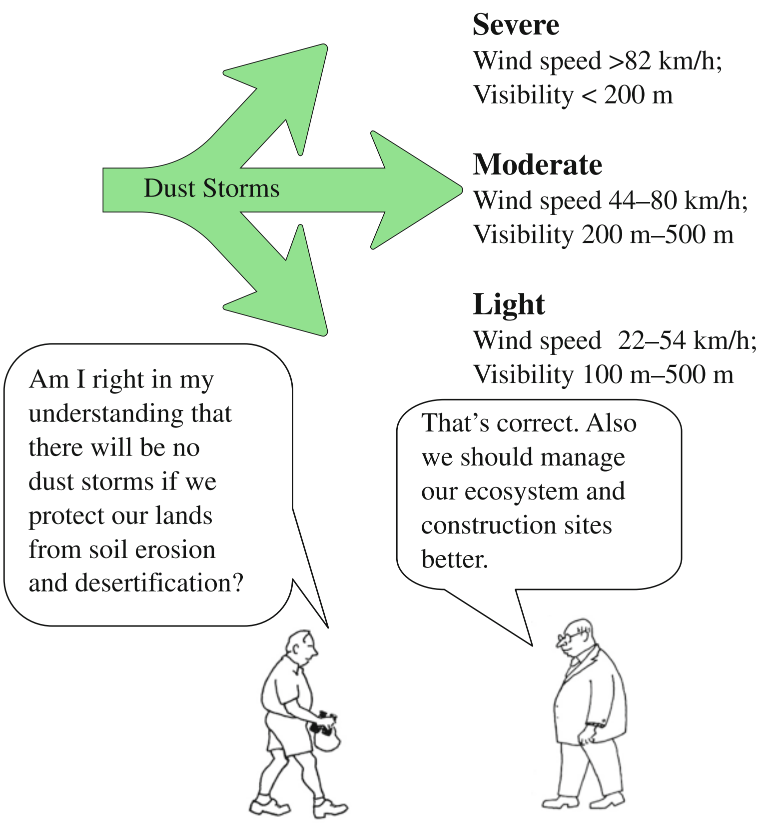


Fig. 3.56 Preservation and protection of green areas and afforestation programs are essential to counter dust storms

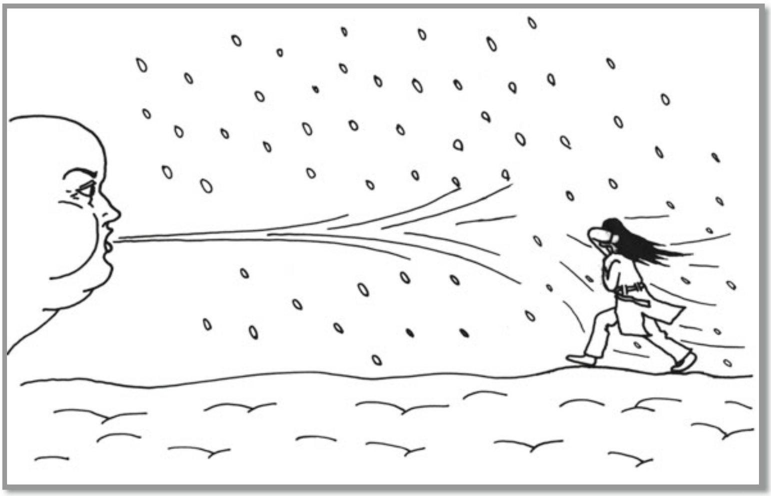


Fig. 3.57 We face strong cold winds and low visibility in a blizzard

Snowstorms and Blizzards

The term *blizzard* stands for fiercely blowing snowstorm with strong winds and very low visibility, Fig. 3.57. A snowstorm is called a blizzard when wind speeds exceed 56 km/h, mercury drops below −7 °C and storm lasts for 4 h and more. A local newspaper used the term blizzard for the first time to report the severe snowstorm which swept the States of Minnesota and Iowa in the United States of America on 14 March 1870.

Blizzards are reported from many parts of the world, especially from Atlantic, Antarctica, Canada, Russia, Northern Europe, the United Kingdom, and the United States of America. The most talked about blizzard in the recorded history is of 12 March 1888 in the United States of America when a fierce snowstorm hit New Jersey, New York, Massachusetts, and Connecticut shortly after the midnight. The observed wind speeds exceeded 72 km/h with snow drifts in excess of 50 ft.

Blizzards in Antarctica

Antarctica is an abode of blizzards. When the Indians first stepped on the continent of Antarctica in March 1982, they named their station, built on the surface of the ice shelf, as Dakshin Gangotri. The party faced blizzards after blizzards. Every blizzard that hit the Dakshin Gangotri left behind a load of snow over the roof of the station. The added load of snow made the foundations of the station to sink as the time passed. The sinking eventually made the station to look like a deep basement. A time came when vertical ladders were required to access the station.

This arrangement did not hold for long and eventually the station had to be decommissioned in 1989.

The second station, named Maitri too was not spared by blizzards. A study conducted during the period 1990–2005[11] revealed that nearly 21 blizzards hit Maitri station annually. Of these, the maximum number of blizzards occurred in the month of August. It experienced about seven blizzard days with wind speeds on the order of 100-kt and duration ranging from a few hours to a couple of days.

R. S. Gangadharan, leader of India's Antarctica Expedition that setup the station Maitri[12] spoke of "icy winds" blowing at 250 km/h and mercury dipping to minus 45 °C and crevasses deeper than a 10 storied sky scrapper."

Dr Abhijeet Bhatia, a member of the 27th Antarctica Expedition, while describing a blizzard said,[13] "visibility is reduced to just an arm's length with wind speeds reaching 200 miles per hour, snowfall is horizontal instead of vertical and hits you like a thousand needles.........We may be holding a person's hand but we are not able to see him."

Men who Stole Thunder and Played with Lightning

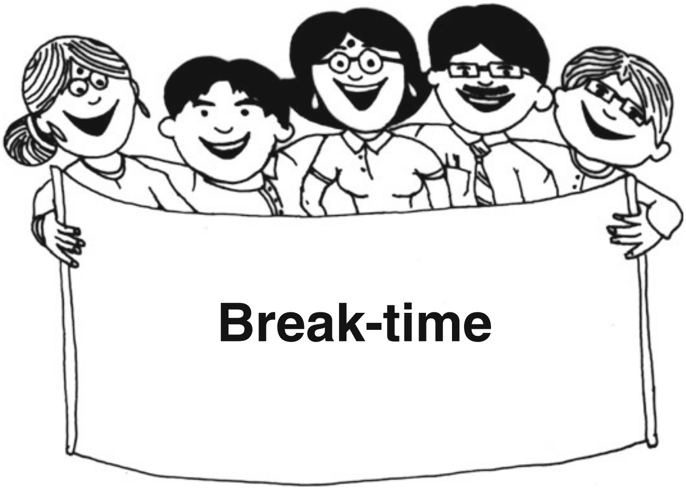
- George William Richmann (1711–1753), a Swedish physicist working in Russia, was the first to tell us, as far back as 1753, that clouds carry electrical charge. Moments after the success of his experiment, he was punished by a bolt of lightning for revealing the secret. His assistant Lomonosov, who survived the lightning, told the story.
- Benjamin Franklin (1706–1790), born in the family of a candle maker, was the first to light the candle of knowledge to illuminate the electric nature of lightning. He did so through a systematic program of scientific adventure in the second half of the eighteenth century. He deducted that since the clouds are electrically charged, lightning must also be electrical in nature. It was on 15 June 1752 that he succeeded in drawing an electric charge from a rain cloud. In order to position his experiment closer to the cloud, he used a kite instead of a rod. He insulated his hand by wrapping a silk ribbon to safely observe electric sparks by attaching a key to the damp kite string.
- Thomas Francois D'Alibard of France was the first to demonstrate experimentally in 1752 that during a thunderstorm, sparks jumped from an iron rod.
- Friedrich Pockels (1897–1900) was the first to study the magnetic field induced by lightning which made it possible for him to estimate electric current values.
- Charles T.R Wilson (1869–1959), a Scottish physicist and a Nobel Laureate, was the first to develop a cloud chamber in 1912 to study lightning discharges by studying the structure of thunderstorm charge. Ernest Rutherford called it

[11] See Lal and Ram (2009), pp. 39–50.

[12] See Express News Service (2005).

[13] See Bhatia (2008).

"the most original and wonderful instrument in scientific history." He published theory of thundercloud electricity in the proceedings of Royal Society, London in August 1956.



Break-time question 5: Is the *approaching* thunderstorm a bigger threat than a thunderstorm *receding* from your area? What is considered to be a safe distance from lightning attack?

Answer to Break-time question 5

The threat of a lightning strike is the highest when a storm is either approaching or exiting your area. Generally, the threat is very low to negligible if you do not hear repeat of sound of thunder for 30 min. According to John Ogren, meteorologist-in-charge of the Indianapolis NOAA National Weather Service, the golden rule is "if you hear it clear it. If you see it, flee it. Next time a thunder roars, go indoors."

The famous 30/30 rule is that go indoors if the time between lightning and thunder is 30 s or less. If for 30 min you have not heard the repeat of the sound of thunder, you may attend to any emergency outdoors.

The distance of about 10 km from lightning is generally considered safe.

Cyclones, Hurricanes, and Typhoons

See Fig. 3.58 for details.

Cyclones: Three Names but One Hazard

Tropical Cyclones

A cyclone in the Indian Ocean is called a tropical cyclone. The Greek coined the word *Kyklos* to describe cyclones because to them the cyclones looked like a coil of snakes. Henry Paddington, a meteorologist by profession, coined the term cyclone as he saw it as a whirling storm exhibiting circular motion.

Hurricanes

A cyclone in the North Atlantic Ocean is called a hurricane. The American word *Huracan* was introduced by Columbus and that eventually became *hurricane*.

Typhoons

A cyclone in the Western Pacific Ocean is called a typhoon. The term *typhoon* is derived from the word *tai* as the people of south sea coast of China called it. In Japan, a typhoon was called *No waki*.

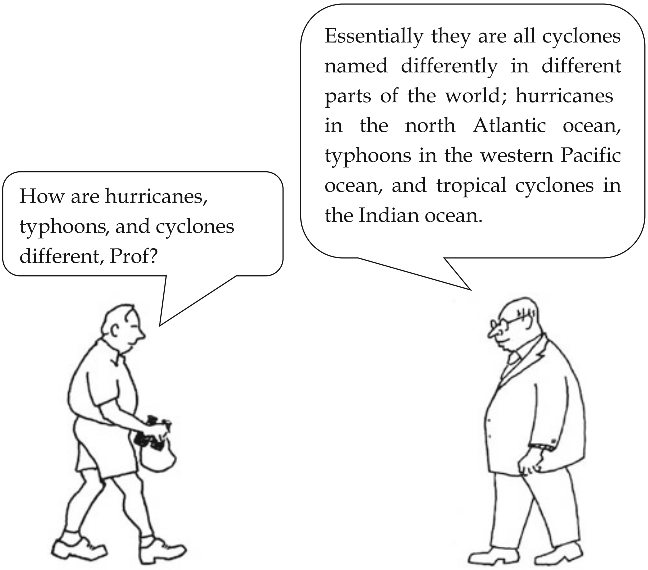


Fig. 3.58 Three names for one hazard

The Force of the Wind and Its Power

> The force of wind followed a simple mathematical formula: force equals velocity squared. A 300-mile-per-hour wind was not three times as powerful as a 100-mile-per-hour wind; it was nine times more powerful.
>
> See Mathis (2007), p. 134.

Wind power is influenced substantially by distance from the water front, topography of land and its exposure. For example, about 70 km inlands from the coast, its value would drop to about half. The damaging potential of wind soars high when it carries a charge of debris.

A Cyclonic Ring—from its Eye to the Outer Boundary

See Fig. 3.59 for details.

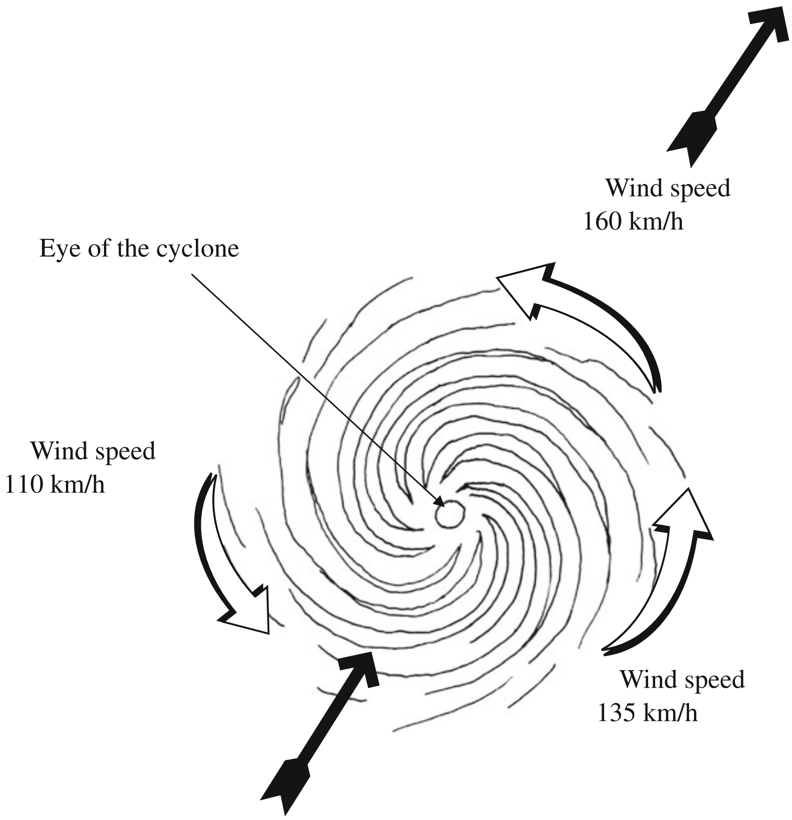


Fig. 3.59 The horizontal section of the ring of a cyclone from its eye to the outer boundary of the cyclonic storm. Mark the variations in the wind speeds around the ring. Strong cyclonic winds may stubbornly persist for many hours over areas in the radius 50–150 m. Gales may occur in relatively much larger area. Moreover, cyclones may attain heights of more than 10–15 km from the sea level from where they rise

The Power of Cyclones

Cyclones are so hugely powerful that it is a child's play for them to tear apart whatever blocks their path, blow away building roofs, pound coastal areas, create storm surges and gusty winds, flood vast landmasses, and ruthlessly flatten the landscapes. Only grass survives because of its exceptional humility!

According to one estimate, 90 million tons of water vapor is required for a cyclone to form and 5×10^{11} J of energy is added to a cyclone every hour. If force is measured in dyne and distance in centimeter, energy which is the product of the two, will have the unit of erg. Since it is too small a unit to deal with hurricane intensity cyclones, unit of Joule (1 J = 10 million ergs) is preferred. Remember this represents only the kinetic component of energy of surface winds, which excludes potential and latent energy components. Cyclone damaging power is immense, Figs. 3.60 and 3.61.

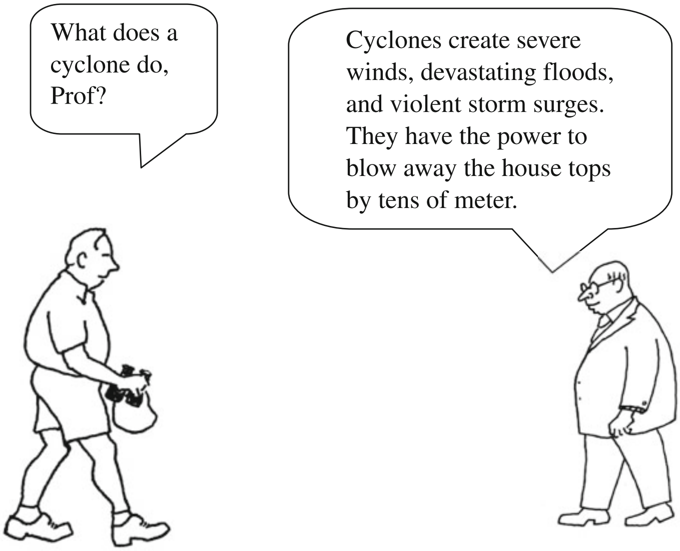


Fig. 3.60 The power of cyclones

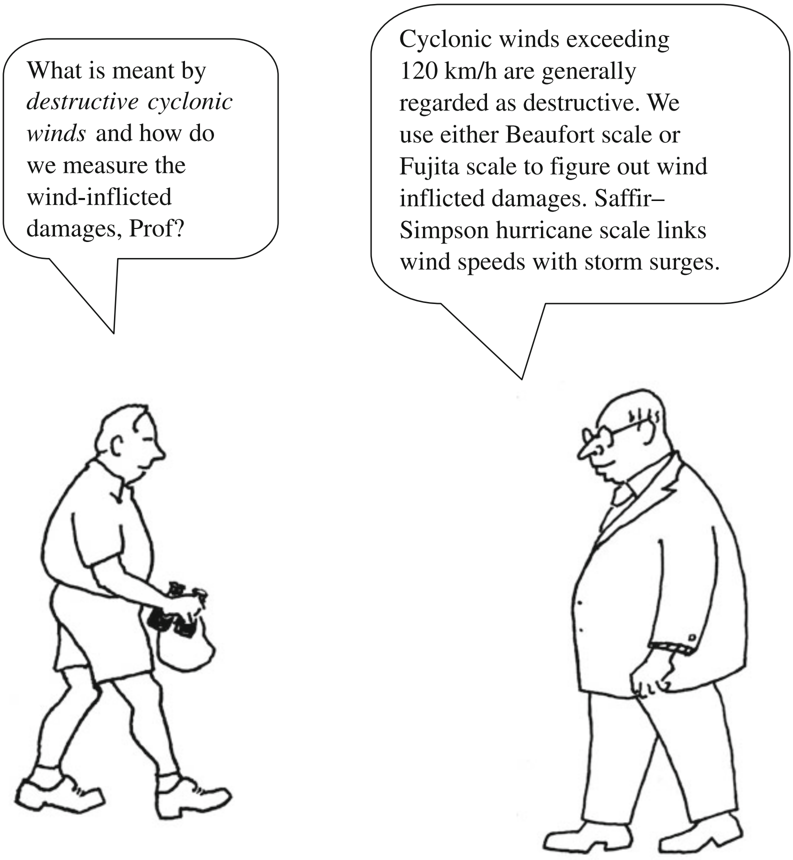


Fig. 3.61 More than 200 years ago, Sir Francis Beaufort, gave us what has come to be known as the 12-point Beaufort scale (Fig. 3.62). There is a very gradual transition from the state of calm at B_0 of the scale to the hurricane force at B_{12} in terms of wind speed. Fujita scale of wind damage is also based on damage surveys

Destructive Cyclonic Winds

See Fig. 3.62 for details.

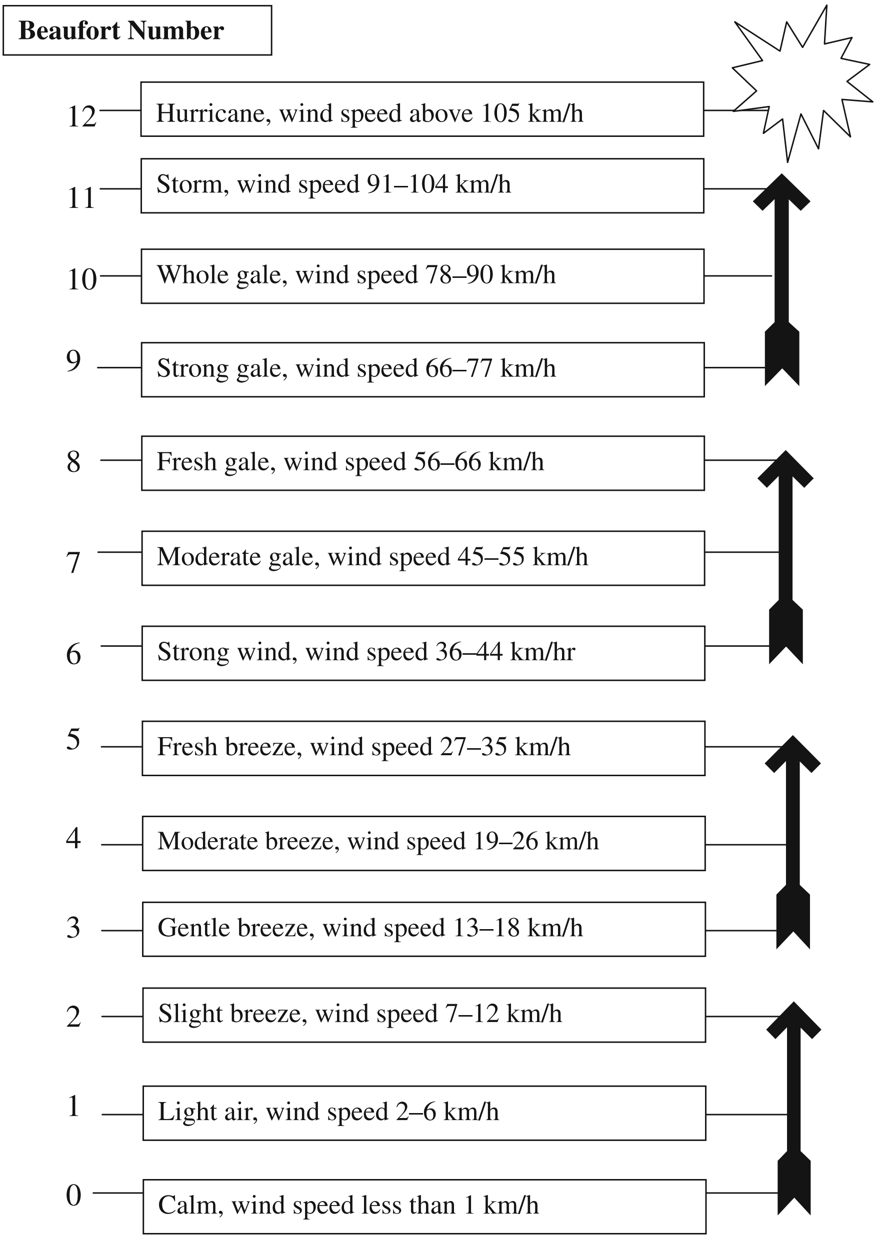


Fig. 3.62 Beaufort scale of Wind Force

Fujita–Pearson Scale of Damages

F_0 18–32 m/s (40–72 mph): Light damage; some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage signboards.

F_1 33–49 m/s (73–112 mph): Moderate damage; the lower limit (73 mph) is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the road.

F_2 50–60 m/s (113–157 mph): Considerable damage; roofs torn of frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.

F_3 70–92 m/s (105–206 mph): Severe damage; roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted of ground and thrown.

F_4 93–116 m/s (207–260 mph): Devastating damage; well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.

F_5 117–142 m/s (261–318 mph): Incredible damage; strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; incredible phenomena will occur.

F_6–F_{12} 143 m/s to Mach1, the speed of sound (319–700 mph): The maximum wind speeds of tornadoes are not expected to reach the F_6 wind speeds (Figs. 3.63 and 3.64).

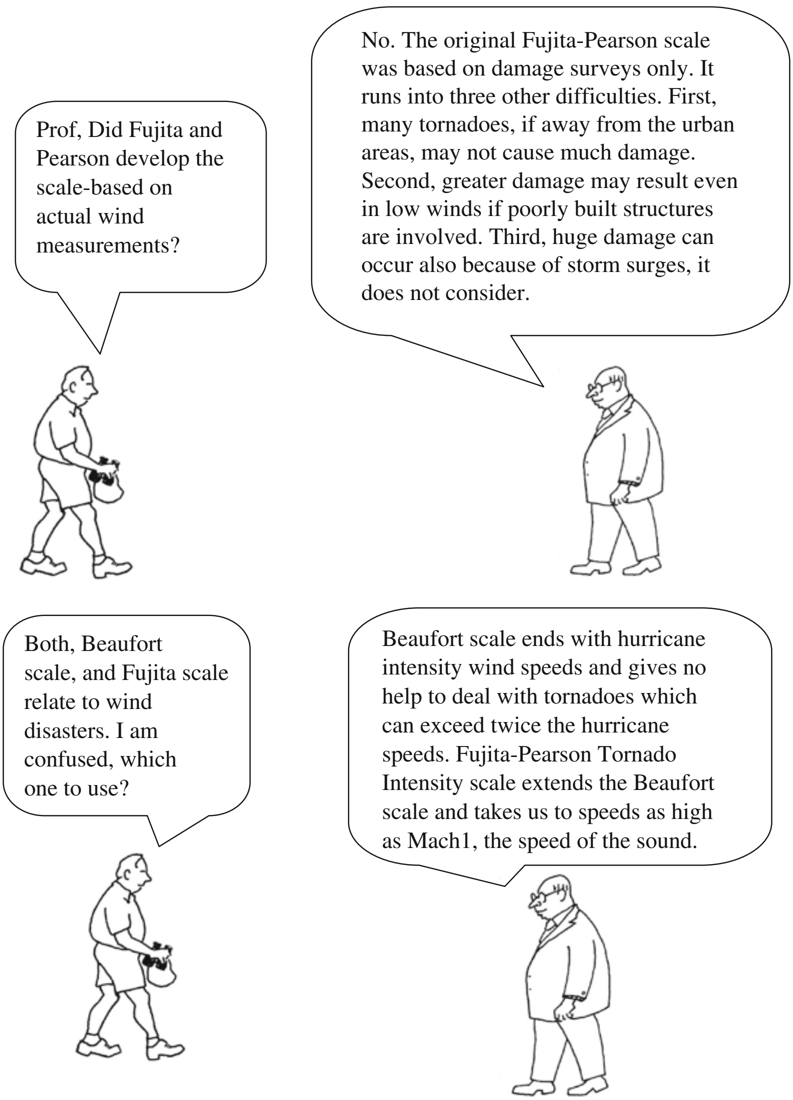


Fig. 3.63 Characteristics of different scales

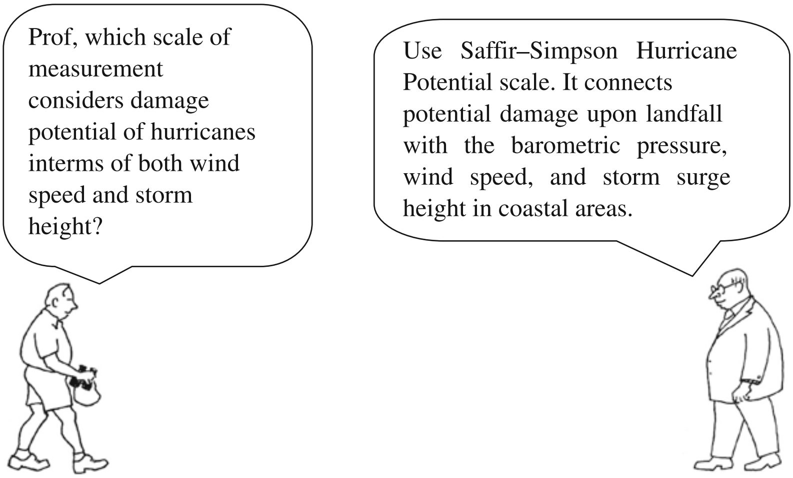
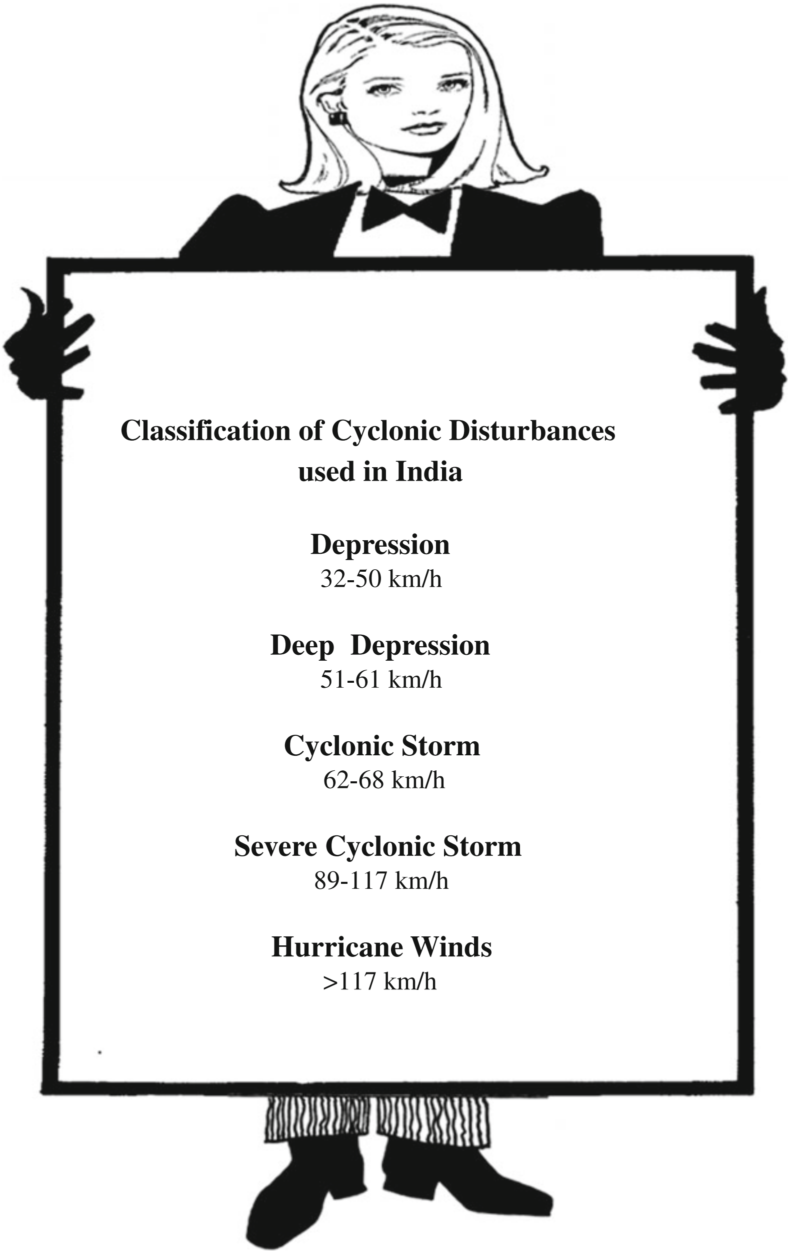


Fig. 3.64 Scale for measuring damage, Saffir–Simpson Hurricane Scale

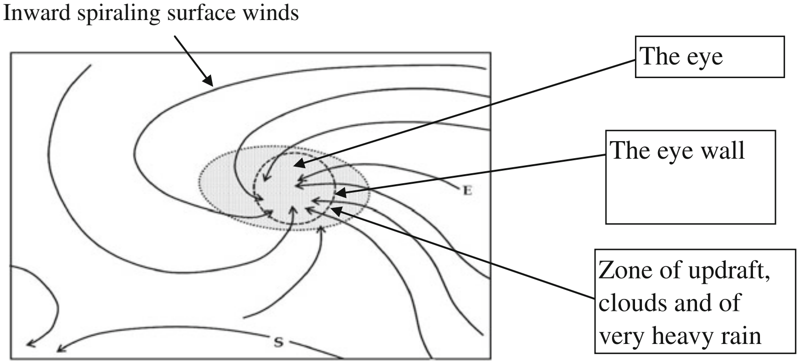
Scale number (category)	Sustained winds (mph)	Damage	Storm surge (ft)
1	74–95	Minimal: unanchored mobile homes, vegetation, and signs	4–5
2	96–110	Moderate: all mobile homes, roofs, small craft; flooding	6–8
3	111–130	Extensive: small buildings; low-lying roads cut off	9–12
4	131–155	Extreme: roofs destroyed, trees down, roads cut off, mobile homes destroyed, beach homes flooded	13–18
5	More than 155	Catastrophic: most buildings destroyed, vegetation destroyed, major roads cut of homes flood	Greater than 18



Basic Facts about Tropical Cyclones

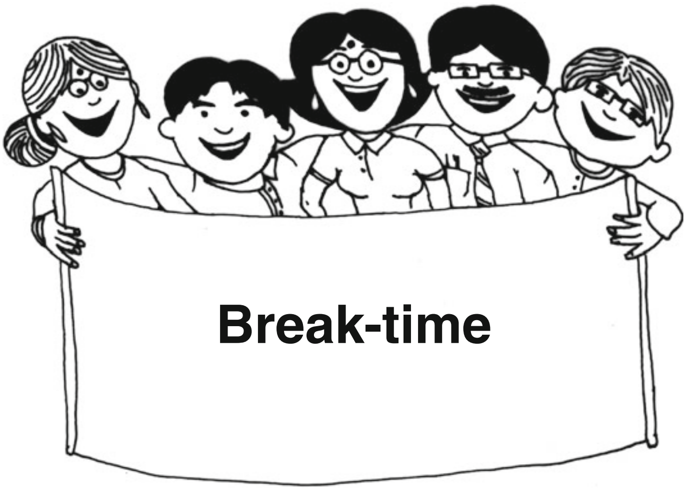
Basic Facts About Tropical Cyclones

- Tropical cyclone, as the name implies, is formed in the tropical belt between 5° and 30° latitude on the both sides of the equator. There are no tropical cyclones between 0 and 5° latitudes because of the absence of spin, or the so-called *Coriolis Effect*. Even a well-developed cyclone formed in the higher latitudes gets robbed of its spin the moment it falls into this forbidden zone.
- Cyclones are fueled by sustained radiation of the Sun over oceanic waters during long, hot summers. It is for this reason that equatorial tropical belt is an ideal cyclone breeding ground. When the seawater temperature rises above 27 °C in the upper 50–60 m, a cyclone is already in the making.
- Cyclones are giant heat engines of nature which relieves the oceanic waters of its heat energy through persistent gusty winds, heavy rainfall, huge storm surges, and intense flooding. Severe cyclones have the energy enough to raise seawater level, temporarily, by a few meters.
- The mechanism of formation of cyclones is fascinating. As the seawater temperature rises, heat energy gets stored in the seawater and warm humid air begins to rise. Being lighter, it rises up creating low pressure depressions below 1,000 millibar. The updrafts of humid winds cool the upper atmosphere, form clouds, and grow ice balls. When the clouds fail to hold ice balls, down drafts are created. The down drafts then meet updrafts generating stray thunderstorms with mild surface winds. Gradually, surface winds gather in strength and they begin to rotate around and into the center of a growing storm, called the eye of the cyclone.
- Wind speeds are strongest on the eye wall. Inward spinning surface winds struggle to spiral around the eye of the storm but because of their converging nature, surface winds fail to reach the eye but instead shoot up creating a funnel in the center of the storm.



- Cyclone winds weaken with the increase of height but a cyclone may gain in strength when winds in the higher altitude are weaker. When surface winds exceed speeds of 63 km/h, we get storms. When they exceed 119 km/h, we get hurricanes.

- The eye of the storm measures between about 20–50 km in diameter and is characterized by light winds and sparse clouds. The cyclonic ring surrounding the eye is made of strong winds, in the diameter range of between 100 and 300 km. The zone of gale may, however, extend to about 600 km in diameter.
- The depth of a cyclone may range between 12 and 20 km, measured vertically from its top to the sea level.
- Landfall occurs when cyclones weaken, influenced by low pressure systems, and higher latitudes.
- The wind circulates in an anticlockwise direction in the northern hemisphere and in a clockwise direction in the southern hemisphere due to Coriolis Effect.
- Cyclones are self-fueling storms. If starved, they may die out in a day. When well fed, they may survive for 2–3 weeks depending on the oceanic condition along its track and proximity of the nearest lands.
- Cyclones are assigned masculine and feminine names, alternatively. Sometimes they are also identified by the year of their formation and the annual count.



Break-time question 6: Why and how are hurricanes and cyclones named?

Answer to Break-time question 6

A famous quote of William Shakespeare reads, "What's in a name? That we call rose by any other name would smell as sweet."[14] It is also true of hurricanes: No matter what name we give them, their power and punch would not change. Then why and how hurricanes are named?

Hurricanes are named for several good reasons. Two different storms developing in the same area, if not named, may cause confusion in their identifications. It is so much easier to communicate, if hurricanes could have names which are easy to remember. It is only because of the practice of naming hurricanes that we are able to easily recall and correlate past events worldwide without messing up with their latitudes and longitudes.

Earlier, it was the practice to give hurricane the name of the place it devastated. Galveston Hurricane of 1900 is one such example. Similarly, if a hurricane happened to arrive on a historic day, it was named after that day. The hurricane of 26 July 1825 which struck Puerto Rico was named after Saint Santa Ana. The Labor Day Hurricane of 1935, as the name implies, got identified with an all too familiar an event.

In the year 1950, US Weather Bureau began to use phonetic alphabets to name hurricanes. The *hurricane Able* of 1950 is an example. Decisions to name subsequent hurricanes as Baker, Charlie, Dog, Easy, etc., were as per the predecided list. In 1953, hurricanes were identified with women's names, the first of which was Alice, starting from alphabet A. Following the simple logic, the name of the third one, Carol, started from letter C, and the sixth one named Florence, started with letter F.

Anna, Alma, Arlene, and Abby were the first named storms in 1969, 1970, 1971, and 1972, respectively. In 1979, both male and female names were intermixed. The World Meteorological Organization has established a convention to name hurricanes which is being followed worldwide (Fig. 3.65).

[14] Shakespeare. Romeo and Juliet (II-ii, 1–2).

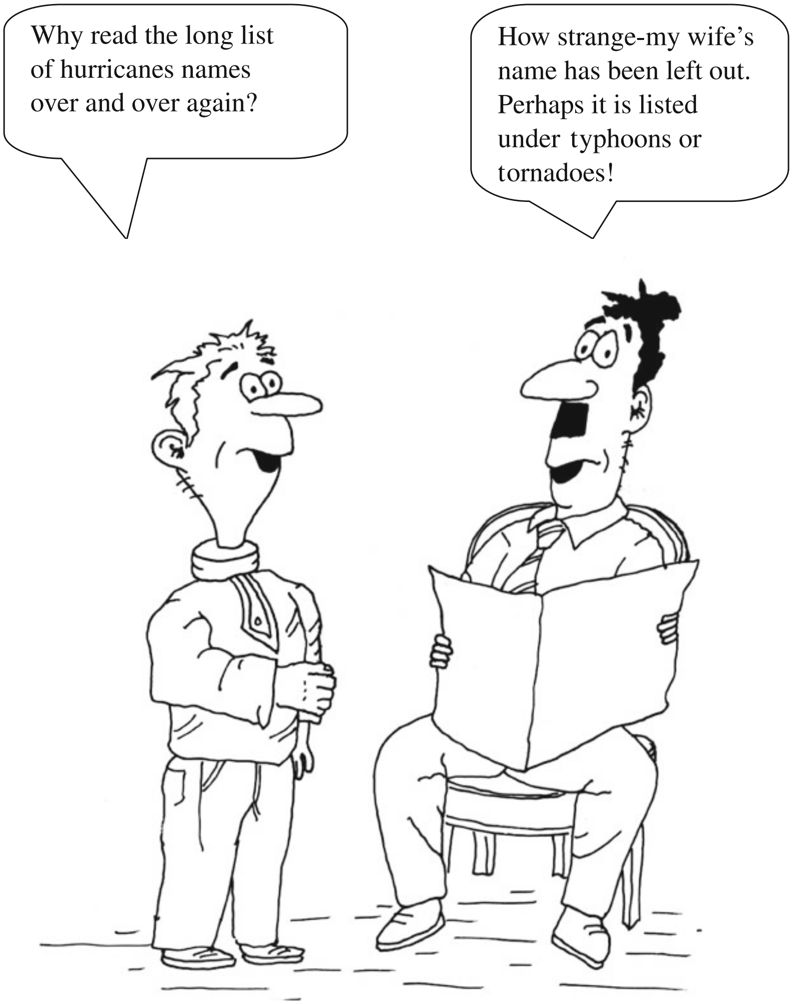


Fig. 3.65 On naming hurricanes

Floods

He seems to be a known face. I perhaps saw him in the Flood Safety Crash Training Program.[15]

Floods and Flood Disasters

The term flood[16] means inundation of lands by water. In the context of disasters, it is appropriate to regard flood as a hydrogeological hazard. In nature, flooding per se is not always harmful. In fact, it is the way nature transports soil from the mountains to create fertile plains for agriculture. However, a flood hazard becomes a flood disaster when the flooding is so severe that it begins to kill people, drive them out of their homes, destroy property, ruin crops, dislocate communication systems, waterlog roads, erode mountain slopes, create landslides, and above all,

[15] Cartoonist: Murad Ali Baig, published in Swagat Magazine of January 2001, reproduced with the permission of the Editor-in-chief of Media Transasia.

[16] The term *flood* comes from the old English word *flod*.

reverse the process of development. In the fury of floods, bridges get destroyed, embankments and retaining walls fail, sewerage systems get dislocated, and ground water gets polluted. Flooding involving turbid waters can drown people and animals even when water depths are shallow.

Flood disasters rank among the most frequent and devastating disasters. They are considered only second to the disasters due to droughts in terms of their overall impact on the mankind. Simply speaking, floods mean too much of water and droughts mean too little of water. It is painful to see floods killing people because of excess water in one part of the globe and droughts killing people because of water deficiency in some other part. Take for example the floods of July 2010 in Pakistan. Because of these floods, one-fifth of the land area of Pakistan got submerged and about 9.2 million people were affected of which nearly 5.2 million needed humanitarian assistance. This is comparable in consequence to the July 2011 drought in the Horn of Africa which affected 11.4 million people.

Causes of Disastrous Flooding

Flood disasters can occur because of a variety of causes such as cyclonic winds, storm surges, bursting of river banks, invasion by tsunami waves, excessive rainfall, and poor land management. Factors such as deforestation, human manipulation of watersheds, abnormally high rainfall, rapid snow melts, bursting of glacial lakes and of landslide dams, choking of natural drainage channels, and poorly managed water systems are all responsible for flooding. Rapid and often unplanned spurt of human settlements in the flood-prone areas is yet another major cause of flood disasters. An excellent example of this is the floods of December 2005 in city of Chennai in India, Figs. 3.66 and 3.67. Urban floods being sudden, the water levels in the low-lying areas rapidly rose forcing people to evacuate their houses. Since poor people had nowhere to go, they had no choice but to return to their respective locations while the flood waters were still receding, Fig. 3.68.

Vulnerability to Flooding

People living in places like low-lying areas, poorly drained catchments, densely populated towns and cities on river banks, and coastal areas are highly vulnerable to floods. Vulnerability is particularly high when cyclonic floods and tsunamis invade coastal areas and when cloud bursts swell rivers which breach their banks. Major disasters have been traced to situations involving high vulnerability and absence of coping mechanism, especially in the highly flood prone areas.

Fig. 3.66 The above advertisement board speaks of 'colors of life'. Hundreds of victims of 2005 Chennai floods were forced to leave their homes with nowhere to go right under the shadow of the board (*Photos* by the author)

Fig. 3.67 The advertisement boards were changed even before the fortnight of the flooding nightmare could end. The speed with which the business world is able to recover and move ahead should be the envy of disaster response and management teams (*Photos* by the author)

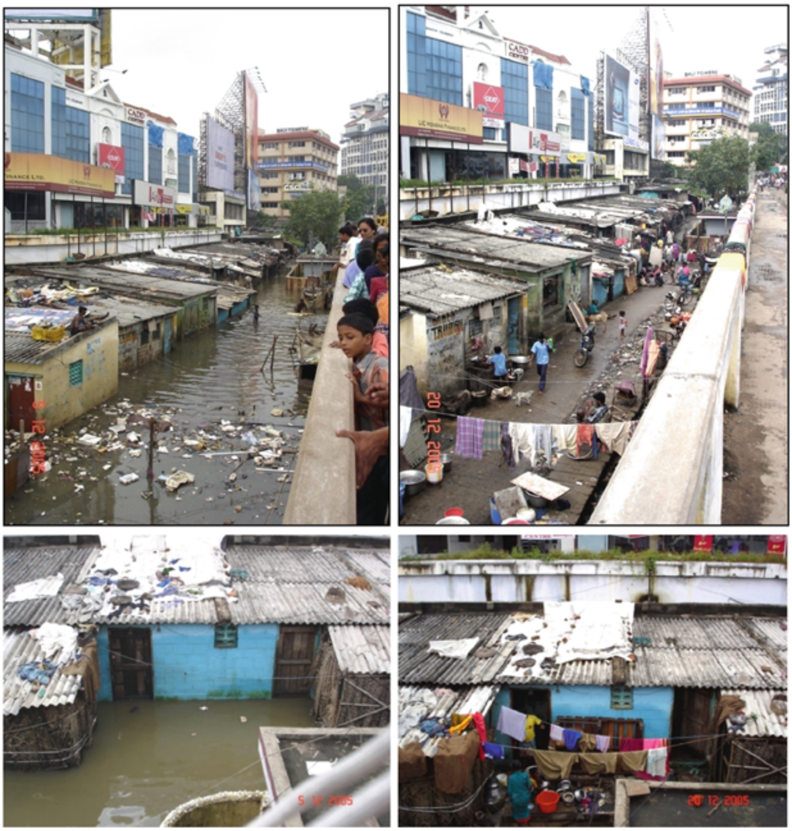


Fig. 3.68 The two sets of pictures show the plight of the flood victims of December 2005 in the urban areas of the city of Chennai in India. Thousands, rendered homeless, returned to their homes within a fortnight even before the flood waters could fully recede. For them, upon their return, the threat of flood was replaced by the threat of epidemic. The high water mark seen in the picture (on the *bottom left*) was unprecedented and is being regarded by the local urban planners as a sign of bigger floods in future. (The above photographs were taken by the author on the 5 December 2005 soon after flooding and on the 20 December 2005 when the people began to return to their homes

Types of Floods

Flash floods are sudden. The time period ranging from a few minutes to less than 6 h is generally regarded as *sudden* although in many cases, from disaster safety point of view, shorter flooding time may pose a huge challenge to the emergency response. Flash floods are generally caused by cloud bursts, severe thunderstorms, tropical cyclones, and bursting of landslide dams. Glacial lake outburst floods also fall in this category.

The greatest problem Flash floods pose is the very short time slot between sounding of a *flood alert* and the arrival of the flood. A few minutes of time notice is not generally enough for effective emergency response but a few hours of notice may perhaps facilitate evacuation and save lives. Naturally, a flood alert without the *estimated arrival time* of actual flood at a given location is of a very limited use.

Figure 3.69 illustrates the above point through the story of two different townships, both located not very far from each other at the bottom of two geologically similar catchments. The two catchments were of equal areas but of different shapes—one elongate and the other lobate (Fig. 3.69). Upon arrival of a cloud burst, lobate catchment flooded the township downstream in about 30 min. This alert time was so short that nothing much could be done by way of emergency response and a lot of damage was done by the flood. The same cloud burst took about 6 h to flood the elongate catchment thereby allowing sufficient alert time for emergency response. The whole township downstream could be evacuated and simultaneously all low-lying areas could be drained by pumping out water to rescue those trapped, Fig. 3.70.

River floods are the result of sustained rainfall over large areas or of melting of snow which cause rivers to swell. Unlike flash floods they are slow to buildup thereby making disaster response relatively less challenging. Where a river abruptly changes its course because of the rise of river bed level, the flooding may come as a big surprise to the affected people.

Coastal floods are often associated with tropical cyclones and tsunamis. Wind-induced storm surges and high tides aggravate flooding. Coastal river system too needs watching.

Man-Made Floods

Man-made floods are often the consequence of mindless urbanization. There was a time when for centuries our mountains, rivers, flood plains, and wet lands drained freely because of very little human intervention. With the increase of population and mounting pressure on our lands, people began to cut trees, clear slopes, encroach flood plains, and fill-up natural water bodies to reclaim land for construction wherever they found the possibility to do so. In the process, the freely draining areas got transformed into very poorly drained land masses. With sustained neglect, many of these areas now face the risk of flood disasters especially during the rainy session.

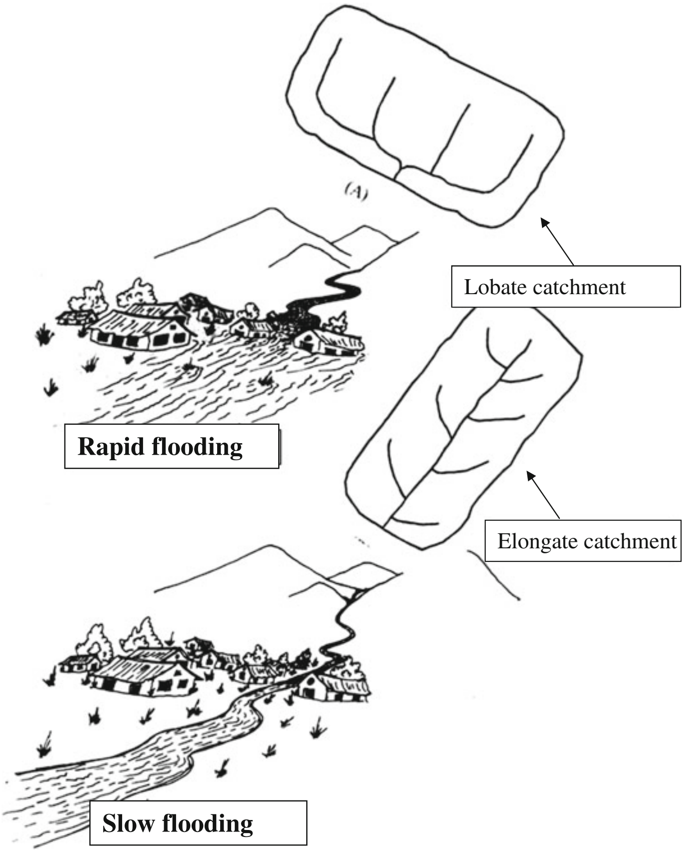


Fig. 3.69 People living in the foothills face flooding which may be sudden or slow depending on the catchments characteristics such as its shape and drainage pattern. In the two pictures, flooding is seen faster in the first case involving a lobate catchment. The flooding is slower in the second case because in an elongate-shaped catchment, water has to flow through longish stream lengths giving more time for early warning and flood response

Flood Disasters and Climate Change

There are various other ways in which we invite floods. We create river diversions, water storage dams, interbasin water transfers, canals, and all kinds of infrastructure in the name of development, very often by flouting the landuse plans and land management regulations and laws.

Cities and townships on the river banks are susceptible to flooding even in the normal times because of the encroachments, poor land drainage, and human interference. Increasing trends of high intensity rainfalls, cloud bursts, and excessive snow melt due to climate change have combined with river bed rise due to siltation to make rivers highly flood prone. If threats of climate change persist,

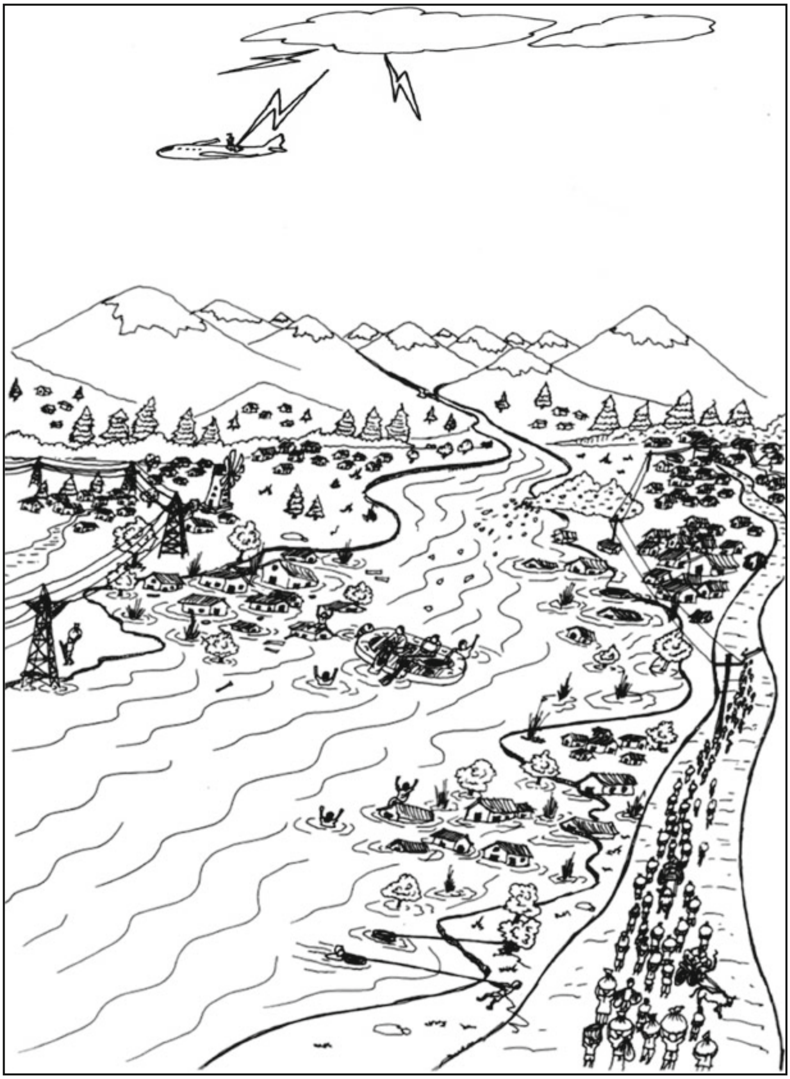


Fig. 3.70 An artist's view of the township which got flooded by an elongate-shaped catchment (described in the story). The people of this township got about 6 h of alert time to be able to evacuate all the vulnerable people. On the other hand, sudden flooding of the 'other' township by the lobate-shaped catchment caused much heavier losses

bursting of river banks and consequent inundation of urban areas may lead to higher frequency of flood disaster. We may also find added threats to low-lying areas and coastal areas because of the climate change-induced sea level rise.

Flood Mitigation Measures

Flood mitigation measures must necessarily be fashioned to suit location-specific situations. The most basic approach is to improve landuse planning, land management practices, and land drainage. Afforestation of denuded lands reduces overland flow and its destructive erosion potential. Structural measures to check floods include construction of embankment dams with features to regulate excess flood water, and construction of river bank and coastline protection works.

Early Warning Against Floods

Early warning against floods have become increasingly more reliable because of the advances in the systems and technologies of reliable weather forecasting, mapping, real-time data analyses and substantial improvement in our ability of data-based decision making, contingency planning, and in the swiftness of the emergency response. It is now possible to improve the lead time for emergency response by efficient use of information communication technologies including visual media and cell phones.

Experience has revealed that best of the early warnings have failed in some cases because of the tardy response of communities due to their lack of understanding of warning signals and of their role during a declared emergency.

Community Awareness: The Key to Flood Safety

Well-informed communities can play a significant role both in flood risk and flood loss reduction as also in improving emergency response to flooding. Communities are usually the first responders to disasters. They are, therefore, best positioned to provide critical inputs to future flood forecasting, early warning, and emergency response. As it currently happens, engineers and urban planners model floods and use hydrological maps and meteorological data to figure out all that needs to be computed. For example, for a given area, they are able to delineate areas likely to get submerged, predict intensity and duration of flood, estimate possible rate of water rise at critical locations, figure out probable depth of submergence, and likely period of inundation. All these predictions are just predictions without validation of assumptions made in the analysis or end results. Communities, when faced with floods, precisely know what is happening on the ground. Because of this, alert communities have ready and reliable answers to the questions relating to time of arrival of flood, rate of rise of flood water levels with time, areas of submergence, and durations of submergence, direction of drainage, speed of flowing water, and extent of likely damages. These are precisely the answers against which urban planners and engineers can test their models and theories.

The other point of great practical significance is *fixing* of three critical water levels—flood warning level, dangerous flood level, and exceptional flood level—around which early warning and emergency response is centered. Communities are best placed to know these levels, most reliably, regardless of what flood management models might predict. Once these critical levels get reliably established and formally notified by authorities for different areas, smart communities are most likely to comprehend danger and act even before a formal flood alert is sounded.

Communities living in the mountainous areas are aware of the fact that every flood brings a load of debris with it. Increase in load of debris will imply increasing levels of slope erosion at the higher elevations. With this day-to-day living experience, communities should be able to link slope erosion with factors such as deforestation, overgrazing, and nonengineered construction. It should then be easier for the communities to convince authorities and compel corrective action.

Communities know that improved drainage of the area they live in can dramatically reduce risks due to a flood. By directly observing floods as they come, communities will themselves be able to map the waterlogged areas, figure out the direction of flood water flow, and clear the blockade to drainage, if and when found.

Quality of community involvement is critical to the success of the planning process. Currently, we see feverish spurt of construction activity to take care of the added population pressure. It does two things—green areas get reduced and natural land drainage gets disturbed. The green areas which once used to breathe and drain freely die for ever as soon as a paved road or a building complex is built over them. Rainwater which used to fall over green areas and recharged ground water table for centuries now add to overland flow resulting in surface flooding. Sensitized communities can act as a pressure group to ensure that new constructions are allowed only if the drainage system is simultaneously strengthened.

Communities living under small catchments are highly vulnerable to flash flood because such catchments quickly respond to even isolated events of short duration-high intensity rainfall or a cloud burst. It is only when the rainfall is continuous and wide spread that river flooding may occur on a regional scale. Emergency responses in the above cases being of different nature, communities should demand capacity building fashioned to their felt needs.

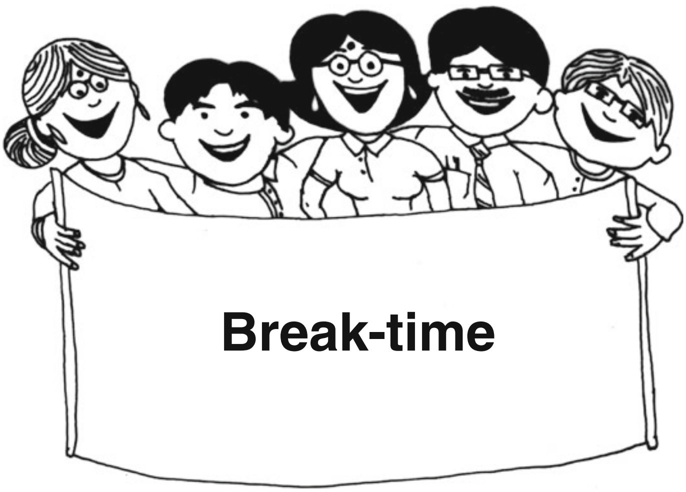
Experience has shown that flood control measures conceived in isolation and implemented in piecemeal are only of a limited help and lasting solutions can only be found in taking recourse to integrated flood management activities. Successful mitigation plans are those which prepare communities to be proactive partners in the implementation of plans and in nursing the culture of safety. It must necessarily encourage teamwork among communities, local government, NGOs, and aid agencies.

Story of Floods in a Zoo and the Plight of Animals

The story relates to the Roosevelt Park Zoo in Minot in the State of Dakota in the United States of America. The park has been facing wrath of the Souris

River[17] floods from time to time, for years on end. The floods of June 2011 crossed the 1881 water mark by more than 1.5 m, beating a 130-year-old record. Since the Souris River straddles the zoo and its protection levees were under the threat of rapidly rising water levels, a big flood was considered imminent. In anticipation of a big flood, the animals of the zoo were evacuated and relocated between 31 May and 1 June 2011. The lessons learned from this story are significant.

Evacuations to safety in flood disasters are as common as the increasing frequency of floods these days. What is not very common, however, is the realization of the subtle difference between the challenge of evacuating human beings and the challenge of evacuating animals from their home in a flood threatened zoo. Here are at least four points of difference. First, the human beings are blessed with communication skills and technology to raise alarms and be heard, the animals are mute and usually left to suffer in silence. Second, the experience of evacuating human beings has matured over decades but the experience of evacuating animals from a zoo or a national park is still in a state of infancy and evolving. Third, human beings get relatively quickly adapted to any new location and unite to fight for their human rights whereas the change of habitat makes animals frightened and keep them restless for a long time. The situation becomes worse where authorities remain insensitive of the plight of animals and their rights. And finally, rescue teams finds it extremely difficult to deal with situations such as transportation of huge animals like giraffes and elephants or managing of ferocious animals like lions and tigers, already in trauma.



[17] The Souris River flows from Canada into North Dakota in horse shoe shape, flowing back to Canada eventually connecting with Red River tributary. Flooding in it is, therefore, affected by water release from Canadian reservoirs, excessive snow melt, and heavy rainfall upstream.

Break-time question 7: Name a simple way we protect the river banks, coastlines and water bodies from attack of water waves?
See Fig. 3.71 for details.

Answer to Break-time question 7

Fig. 3.71 The use of tetrapods for the protection of water bodies, river banks, and coastal belts against tidal waves and water forces has a great advantage over the use of reinforced cement concrete (RCC) cubical blocks because of their unique shape and inherent stability. Unlike the RCC blocks, tetrapods respond to erosion, sinking, and water forces in a manner that they maintain their stability at all times. The above pictures taken by the author are from Maldives which offer a good example of coastal protection by tetrapods. It is usual to number the tetrapods for tracking their locations at any given point on time

Drought and Famine

See Fig. 3.72 for details.

Drought Disasters

What Does Drought Mean?

The term *drought* defies a simple definition. Broadly speaking, it is regarded as a natural disaster in slow motion and is chiefly attributed to prolonged periods of water deficiency in a region with telling impact on people, animal life, biodiversity, and economy.

Different countries have their own definitions of drought. In Bali, a sustained period of only 6 days without rain is seen as a drought. In Egypt, the year river Nile does not flood is taken as the year of drought regardless of the amount of rainfall. In countries like Libya, droughts are declared only after several months of dry spell. Sometimes a distinction is made between meteorological drought, hydrological drought, and agriculture drought.

Water Scarcity and Drought

Water scarcity should not be mistaken as drought. In affluent areas, for example, if enough water is not available to water the lawns or fill the swimming pools then such water scarcity should not mean drought. Water scarcity only means that in any given situation, water supply happens to be less than water demand. The supply of water is generally boosted to take care of the growing demand by constructing dams, water reservoirs, and canals.

Fig. 3.72 An artist's view of a village devastated by a severe drought and famine in which most people of the village perished

Drought means a *severe* water deficiency due to factors such as delayed monsoon, failure of rainfall, long dry spells, and large rainfall variability across the region with the potential to lead to a humanitarian crisis driving population out of the region. Here, *severe water deficiency* is determined as *deviation* from the average or *normal rainfall* of the area. Meteorologists arrive at the estimates of normal rainfall distribution from the meteorological data of the region spread over several decades.

Degree of Severity of Drought

The degree of severity of a drought depends on a complex mix of factors such as intensity, duration, and spread or spatial coverage. These are, however, not enough to fully distinguish one drought from the other without considering the vulnerability of people and the overall impact on environment and economy.

Droughts are generally known to creep in silently but their exits are mostly sticky and stubborn. What is worse, its intensity does keep changing with time history of rainfall deficiency vis-a-vis the normal rainfall, forcing new *normal*. In arid areas, where even with normal rainfall, life is a struggle, rainfall lower than the normal is a sure invitation to drought. On the other hand, in a relatively higher rainfall area, even with somewhat deficient rainfall, drought may pass more or less unnoticed.

Durations of droughts display a wide range of variability, from situation to situation. In some regions, droughts are only occasional visitors inflicting little pain whereas in some other regions, they may be frequent, recurring, and prolonged, with very painful dry spells and extreme weather events. Droughts in the Horn of Africa and the Sahel are examples of protracted droughts which have played havoc with the lives of millions of people to the point of a great humanitarian crisis.

> Droughts are the deadliest of the four hazard categories (earthquakes, floods, and storms are the others) and poor countries suffer disproportionately–almost 1 million people died in Africa's drought alone.[18]

Factors Promoting Drought

Factors such as population growth, haphazard urbanization, rural–urban migration, improper use of land, poor water source management, misuse of water, climate change, deforestation, overgrazing, and improper farming methods all promote drought. Drought in turn prevents cloud formation and exposes the landmass to direct solar radiation. Increased solar radiation accelerates evapotranspiration, sowing the seeds of desertification. Desert-like conditions once created tend to slowly grow and eventually get out of hands. Since large-scale land reclamation measures for reversing desertification are often time consuming and expensive, it is wise to resist desertification at the very outset by introducing drought-resistant crop practices, by taking recourse to afforestation and environmental protection and by improving the grazing patterns.

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[18] See World Bank and United Nations (2010).

Drought and Climate Change

Drought promotes global warming; global warming fuels climate change; and climate change is making the hydrologic phenomenon even more complex and assessment of drought far more difficult. Due to climate change, we may have more cases of flooding in drought-ridden areas and more drought-like situations in flood frequented areas.

Famine

A *Famine* is a prolonged and widespread shortfall of food threatening the very survival of the people. Very often, it is caused by a chain of interrelated factors such as crop damage, poor agricultural yield, overpopulation, wastage of food grain, economic backwardness, faulty government policies, and the governance deficit. Many countries have prolonged periods of famine which leads to starvation, malnutrition, and mortality. There is also a direct connection among conflicts, acts of war, and famine because in violence-torned, disturbed, and inaccessible areas, food supply does not easily reach the impoverished populations.

The countries worst hit by famine are the Sub-Saharan African countries. The famine of 1980s in Ethiopia is known for its telling effect, misery, and mortality. In January 2006, the Food and Agriculture Organization forewarned of famine in Somalia, Kenya, and Ethiopia because of severe drought and military conflicts. The humanitarian crisis in Sudan in 2006 created huge problem of famine. According to the World Food Programme, 350,000 people were forced to leave southern Sudan facing acute starvation.

Drought and Famine Mitigation

A drought is not easy to avoid but famine and starvation are avoidable. This is because the national governments can always move their buffer stocks to meet acute pressure of demand. Conservation of ground water, investments in modern farming and agriculture, avoidance of food wastage, progressive government policies, and tightening of law and order apparatus are some of the essential steps to remedy the situation.

Nobel Laureate Amartya Sen finds a down-to-earth connection between absence of famines in the post-independence India and the sensitivities of the democratic governments.

Just as it is said that preparations for war must be done in the peacetime, it is equally true that droughts ought to be fought during normal and excessive rainfall years. Plans put to action after the arrival of a drought will be of limited benefit. With the business as usual and without a proactive approach to drought management, bigger droughts, fueled by climate change and population pressure may make our lives even more difficult.

The Great Indian (Bengal) Famine of 1943

The great Indian (Bengal) famine of 1943 was unquestionably one of the worst human tragedies of the colonial history of India in which the streets of Calcutta (now Kolkata) and rural Bengal[19] were virtually littered with the dead and the devastated. It affected 20 million people of which more than 1 million died of hunger and thousands committed suicide.

The story which began with food scarcity in slow motion reached its climax when the typhoon of 16 October 1942 ravaged Bengal killing more than 40,000 people and robbing Bengal of its cattle population. The situation steadily worsened as the fertile soil cover got removed. The stoppage of the supply of rice from Burma (now Myanmar) because of the Japanese occupation of Burma and the added refugee population began to hurt. Supplies of rice from Orissa and Bihar also dried out about the same time. On top of it, the continued export of rice by the British government from Bengal to Iran and Ceylon (now Sri Lanka) extinguished the last hope. Greedy traders added fuel to the fire of the mounting demand.

Mastram Kapoor (1997) quotes Tarak Chandra Das (1997), a writer of the time, who succinctly described the plight of the people:

> These people were somehow keeping themselves alive in rural Bengal subsisting on roots, leaves and barks of trees. When they arrived in Calcutta, they had to live on the skins of vegetables and rotten fruits thrown into dust bins. They did not hesitate to eat dead mice, cats and dogs.

In a memorandum to the then Chief Minister of Bengal, Sir Jagdish Prasad, a former member of Viceroy's Executive Council wrote the following:

> A man died in front of collector's office. When his body was being removed, a woman standing at some distance, asked these men to take away the dead child in her arms.

In his book, *The Conquest of Famine*, W.R. Aykroyd[20] records the following:

> n August I was traveling by train from Madras to Calcutta…It was customary for the Madras-Calcutta mail to pick up dining car at Kharagpur Junction, some 30 miles outside Calcutta, to provide first and second class passengers with breakfast. I stepped out cheerfully down from my compartment en route for a hearty meal. The whole platform was thronged with emaciated and ragged people, of all ages and sexes, many half dead, hoping to board a train for Calcutta. What I remember is a loud, bleating, wailing noise which the starving crowd made, a combination of begging and misery….I could not eat breakfast in the dining car and went back to my compartment.

[19] Before formation of Bangladesh.

[20] See Aykroyd (1975).

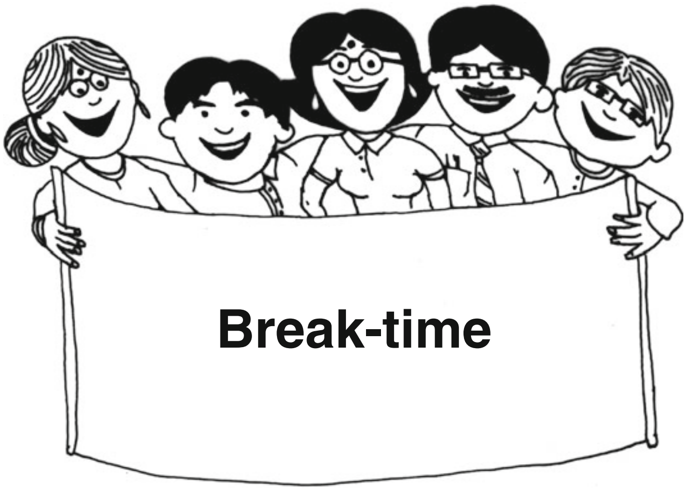
Pandit Jawaharlal Nehru, in his book the *Discovery of India* called famines as “India’s sickness.” In his words:

It was the biggest and the most devastating famine in India during the past 170 years of British domination, comparable to those famines which occurred from 1766 to 1770 in Bengal and Bihar as an early result of the establishment of British rule. Epidemics followed, especially cholera and malaria, and spread to other provinces and even today they are taking their toll of scores of thousands of lives. Millions have died of famine and disease and yet the spectre hovers over India and claims its victims.

The Famine Which Broke a Million Hearts

I have a broken heart. I feel desperate. I can't stand the idea that two million people are in imminent danger of starving to death, many of them children, not because there isn't tons of food sitting in the northern part of Shoa. It can't be distributed. Last spring, Red Cross and UNICEF workers were ordered out of Northern Provinces because of two simultaneous civil wars. I went into rebel country and saw mothers and children who had walked for 10 days, even three weeks, looking for food, settling on to the desert floor into makeshift camps where they may die. Horrible. That image is too much for me. The Third World is a term I do not like very much because we all are one World. I want the people to know that the largest part of humanity is suffering.

—Audrey Hepburn



Break-time question 8: Deaths due to drought are both due to starvation and conflict. Which is the bigger enemy?

Answer to Break-time question 8

Deaths caused by drought are both due to starvation and conflict, and conflict often turns out to be a bigger enemy. "Starvation is easier to prevent than droughts," provided the authorities be both concerned and informed about the people's predicaments. Conflicts and violence, on the other hand, have never been easy to control. The World Food Programme reports that in 2009, violence forced 350,000 people from their homes in southern Sudan, where seasonal rains were meager. Centralized controls do not permit the accurate and timely flow of information and food, and conflicts around the borders make relaxing such controls more difficult.[21]

Fire Disasters

By wind is a a fire fostered and by wind extinguished;

a gentle breeze fans the flame, a strong breeze kills it.
Ovid, Remediorum, Amons, 1,807

Where there is no smoke, there is no fire.
Kaufman and Ryskind

Fire and Water are good servants but bad masters.
John Ray

Fire Disasters

Fire is one of the most commonly faced hazards which frequently turns into a fire disaster for a variety of reasons. Know that there cannot be a fire without the trio of combustible material (fuel), heat (kindling temperature), and oxygen. Fire will continue as long as these three ingredients are present. Just remove or eliminate any one of the three, and you would have extinguished the fire. This is also the fundamental basis of all firefighting operations.

All fires involve chemical reaction which produces heat, smoke, and light. Heat and smoke are the killers and light is hardly any help (Fig. 3.73).

Smoke and darkness make a deadly combination to which people succumb. Different types of fires require different types of fire extinguishers. It is important to know more about water, wet chemicals, foam powder, carbon dioxide, and vaporizing liquid extinguishers.

[21] See World Bank and United Nations (2010).

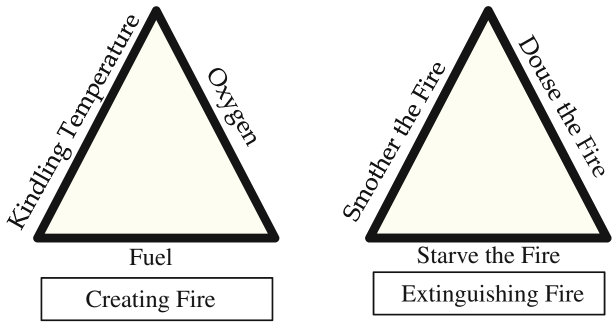


Fig. 3.73 Basics of Fire

Forest Fires

Forest fires are also known as wild fires, bush fires, and brush fires. They threaten almost one-third of the Earth's surface under forest cover, virtually in every continent except Antarctica. Reports of forest fires from the USA, Canada, South Africa, and Australia are common. This is because moisture in atmosphere support growth of trees and dry and hot spells of weather create conditions that fuel the fire.

In contrast to the onset of a drought which is painfully slow, forest fires ignite just in a few seconds, spread faster than the rumors and are as difficult to stop. There are various ways, a fire can spread. It can crawl from bush to bush or jump from one place to another, especially when supported by the wind. Forest fires often spread through forest tops in which case they deprive the living beings of the life supporting oxygen while destroying thousands of square kilometers of the forested lands.

Ecological, economic, and social impact of forest fires is generally multidimensional and defies simple calculations. Inter alia, forest fires erode biodiversity, adversely impact on the microclimate, boost carbon dioxide levels in the atmosphere thereby contributing to global warming, and add to soil erosion. The smoldering smoke may generate transboundary pollution raising political temperatures between nations. On the positive side, it is considered to be an essential agent in the process of regeneration of forests. Beneficial effects of forest fires on ecosystem and biosphere are subjects of continued scientific study.

Forest fires are both natural and man-made. A small matchstick is enough to ignite a forest fire, especially in drier tropical forests. Forest fires have also been caused by other forms of human negligence and deceit like arson and vandalism. Lightning supported by dry strong winds have been responsible for some of the deadliest wild fires. Colliding rolling stones and rubbing of dry bamboos in strong winds may also cause forest fires. Repeated forest fires are known to create grass lands of low productivity.

Fire danger is assessed using weather records, temperature, humidity, and rainfall records supported by satellite pictures. Rising plumes of forest fires can be monitored from the satellites.

The Story of the Uphaar Cinema Fire Tragedy in India

Uphaar Cinema, located in the southern part of the capital city of New Delhi, was engulfed by one of the shocking fire tragedies of the recent times. The cinema hall had a seating capacity of 1,000 with basement below and three storeys above it.

It was the afternoon of 13 June 1997 when the film Border (based on the 1971 war between India and Pakistan) was being screened. The fire killed 59 people and injured 103. Nearly 750 people narrowly escaped death. There was absolutely not even the slightest indication of any fire until the interval time. Upon resumption of screening, smoke reportedly began to appear on the side lines of the cinema screen. According to one eyewitness, he thought "that the smoke seen around the cinema screen was part of the special effect in the thriller movie showing a war scene." Local newspapers reported another eyewitness saying that "he began to feel suffocated around 16:45 pm when the smoke started entering the cinema hall through the ventilators. The smoke was accompanied with unbearable heat."

The origin of the fire was traced to the overheating of a 1,000 KVA electrical transformer in the basement of the cinema hall which caught fire. In the absence of any opening in the basement, the smoke came into the hall via the staircase. And from the hall, it then rose to the balcony. All this triggered stampede. Those in the lower stalls managed to escape. Most of those in the balcony, however, got badly trapped. The balcony and the toilets turned much like gas chambers as the false ceiling caught fire and the rising cloud of billowed noxious smoke came in. Some people, out of sheer desperation, jumped out of the balcony to the hall below. According to a rescuer, "a woman carrying a child jumped out of the lobby window on to the street. He caught her baby, saving the life of the child." Three other people jumped from the second floor on to the street. Majority of people died of stampede and suffocation, without much of an evidence of burns and other injuries.

Faulty transformer, jumble of electrical wiring, narrow gangway, absence of firefighting equipment, missing emergency lights, and some of the permanently locked exit doors all combined to fuel the fire. Delays in firefighting and rescue were glaring. The first fire engine arrived 45 min after the call. "We got stuck in the narrow lanes and heavy traffic of the area" said a fire officer. About 50 fire tenders fought the flames for over 1 h before fire could be extinguished.

According to the High Powered Committee report submitted to the Government of India in 2001, scores of policemen and firemen in gas masks took over. Using three 100-ft hydraulic snorkels, firemen brought out unconscious persons from the upper floors. It took almost 2 h, interspersed with heart-rending scenes of comatose children being brought out, to completely evacuate the theater, with police vehicles and ambulances rushing the victims to nearby hospitals. It was indeed sad to see Raman Sidhu, director of a foreign bank, at the All India Institute of Medical

Sciences in deep anguish because he lost as many as six members of his family and three of his friends in the fire.

Investigation report says that this fire was totally avoidable.

Lessons in Fire Safety

Every individual runs the risk of facing a fire hazard some time or the other and that makes lessons in fire safety essential for all of us. Apart from the knowledge of fire and fire safety equipment, basic principle of fire safety should be taught right from the school level, Figs. 3.74 and 3.75.

Every fire is the same size when it starts

Seneca

What can be a better example than the earthquake triggered Great Tokyo fire of 1923 which took a toll of 140,000 lives. It started small but the small fires quickly joined hands to generate what history recalls as one of the worst fire disasters ever. Small fires were created by toppling of the stoves when the people were cooking at lunch using wood as fuel.

There are many more such examples. The fires which broke in east Kalimantan's province of Indonesia were small to start with, covering about 5–7.5 acres. However, it swiftly fanned out affecting huge areas. In March 1998, it was reported that large fires razed in the Bukit Suharato forest area had flames licking at the main highway linking Balikpapan and Samarinda.

Some 7,400 acres were razed in Bukit Suharato. Fires were also seen blazing in the Kutai National Park, 80 km north of Samarinda. In the year 1997, more than 413,000 acres of Indonesian forests went up in flames. The combined effect of drought and fire reduced the flow of fresh water in the Mahakam river and its tributaries, dramatically lowering their levels and endangering some 200 fresh-water dolphins.

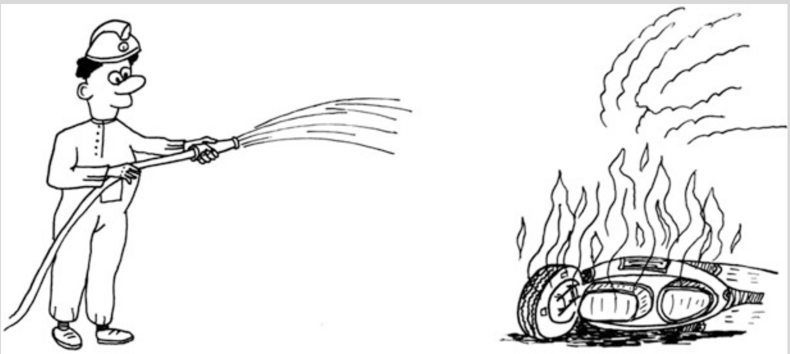
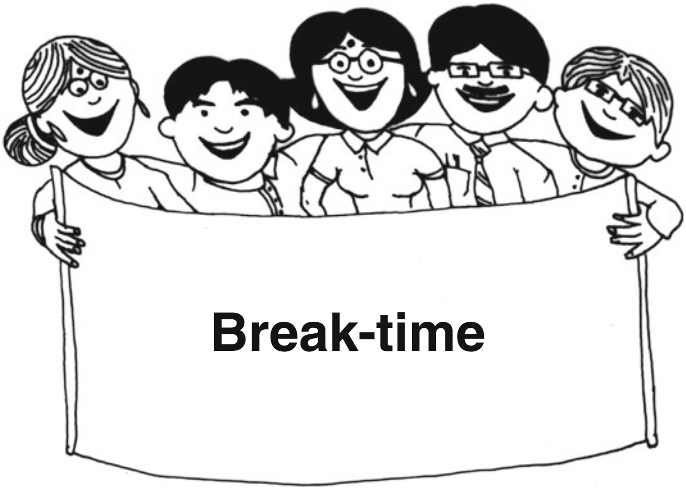


Fig. 3.74 Most of the children could have been saved by avoiding stampede. The fire caused multiple burns only after some of the students got trapped in the hall and got injured due to the stampede

Fig. 3.75 The teachers and students of the school learned from the earlier fire disaster and this time, they were able to escape the fire and save their lives by coming out of the school building in an orderly queue



Break-time question 9: Which is more deadly—smoke or fire?

Answer to Break-time question 9: Smoke is the real Killer.

> "One thing most people don't understand about fires is that the smoke is the main event. It is what makes it nearly impossible to find your way out. Your eyes literally close to protect you from the smoke, and you can't get them open again. It's an involuntary defense mechanism. Smoke is also by far the thing most likely to kill you. Fire fighters rarely see a burned body. Toxic smoke from a smoldering fire can kill you in your sleep before any flames are even visible. That's why it's so important to have smoke detector with a working battery."[22]

Entering fire zone with smoke is suicidal and should be avoided unless you are a fully equipped well-trained fire rescuer.

Stampede and Riots

The term *stampede* comes from the Spanish word, *estamipida* meaning uproar and the ensuing bashing and crushing. Earlier restricted to impulsive, frenzied rush of panic-driven animals, the term now also applies to unruly, undisciplined, and mindless crowd. Added instigation and violent outburst of lawlessness, by accident or design, lead to riots (Figs. 3.76 and 3.77).

[22] See Ripley (2008), p. 124.

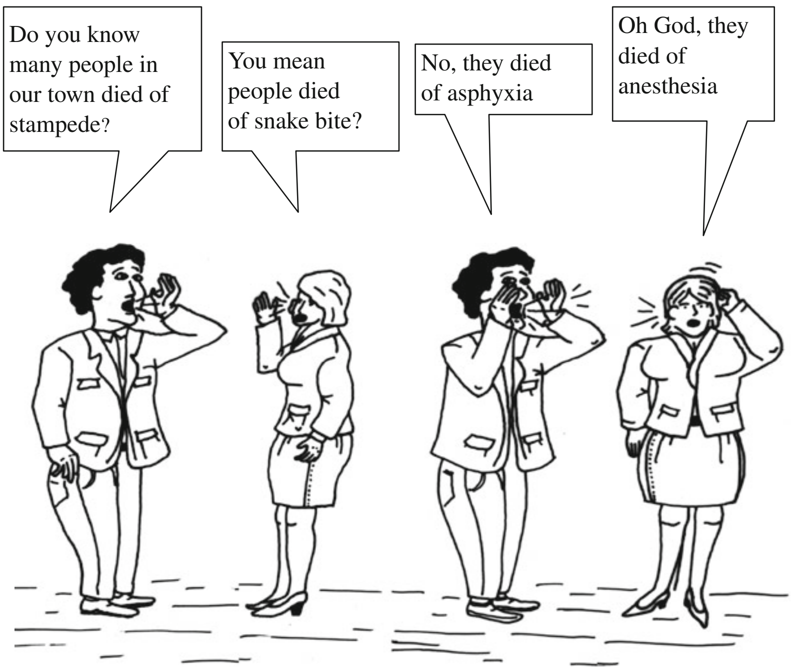
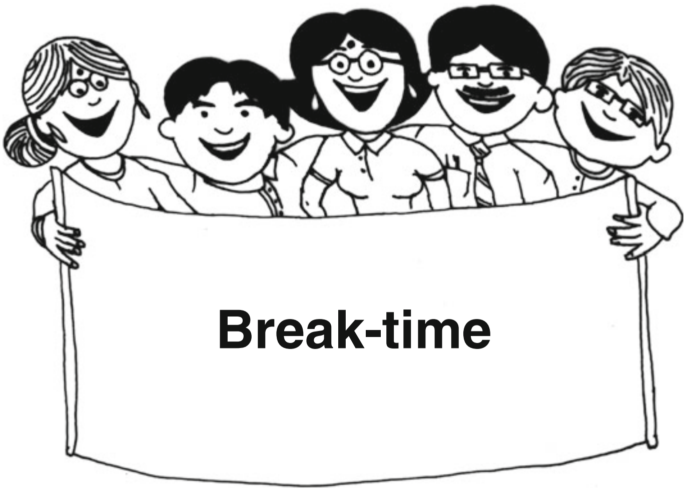


Fig. 3.76 Most people in a stampede die of asphyxiation. It occurs when people trampling over one another put their weight over the upper parts of victim's body causing loss of breathe

Fig. 3.77 "When Heaven sends down calamities, it is possible to escape them. When we occasion our own calamities, it is not possible any longer to live." Riots are entirely avoidable. *Source*: Tae Kea in Mencius, IV, 1, 8 (c. 300 BC)



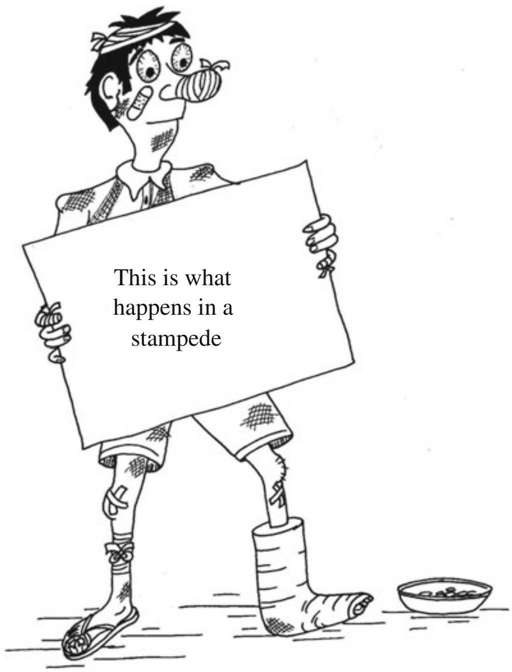
Break-time question 10: Have you ever experienced stampede? What really happens in a stampede?

Answer to Break-time question 10

> "People who die of a stampede do not usually die from trampling. They die from asphyxiation. The pressure coming from all sides makes it impossible for people to breathe, much like getting squeezed in a trash compactor. Their lungs get compressed, and their blood runs out of oxygen. The compounded load of just five people is enough to kill a person. Pressure builds up exponentially, so a crowd quickly picks up the same amount of force as a Mack truck. Humans can lose consciousness after being compressed for just thirty seconds. They become brain dead after about six minutes. They can die without ever falling down."[23]

For what happens in a stampede, see Fig. 3.78.

Fig. 3.78 Why do we create stampede as though there is already not enough trouble around us?



[23] See Ripley (2008), p. 148.

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From Belief to the Basics of Disasters

4

Abstract

The chapter wades through some of the spectacular legends, superstitions, myths, and beliefs that once shrouded natural hazards such as earthquakes, volcanoes, drought, lightening, thunderstorms, and snow avalanches. In the long corridor of time in human history, some of the finest brains in the world split to align themselves either with the magical power of beliefs or with the ever growing myth-demolishing-logic of science. Although we have left scores of myths and beliefs behind, our journey is far from over and many more questions seem to get added as we move forward. It is increasingly being realized that "a scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die and a new generation grows up that is familiar with it" (Max Planck).

Contents

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Legends, Myths, and Beliefs

Centuries ago, natural hazards like earthquakes, volcanoes, and lighting were accepted as God's way to occasionally punish us, when tired of our sins. Epics, mythological stories, and captivating legends tell us about those myths and beliefs, transferred from one generation to the next. Despite this, many of those now in the hall of fame have labored hard to change our perception of natural hazards over centuries that have rolled by. A great deal of clarity has emerged in our understanding of natural hazards since those slow moving days of progress in human history. Today, many of those myths and beliefs about natural hazards have disappeared. Magical advances in science and technology, relentless pursuit for truth, and the expanding pool of knowledge are now putting even the established theories to question.

Beliefs About Earthquakes

There was a time when human race across the globe believed in many myths and beliefs without questioning them and explained away the occurrences of earthquakes in terms of their respective beliefs. For example, people believed that earthquakes occur when mother Earth is shaken by the master of the universe at His will. In some parts of the world, once it was believed that because Earth was supported by a giant turtle that its movements caused earthquakes. In some other parts, people believed that it was not a turtle but the head of a cobra or the horns of a cow that supported the Earth, and it was their movements that triggered earthquakes, Fig. 4.1.

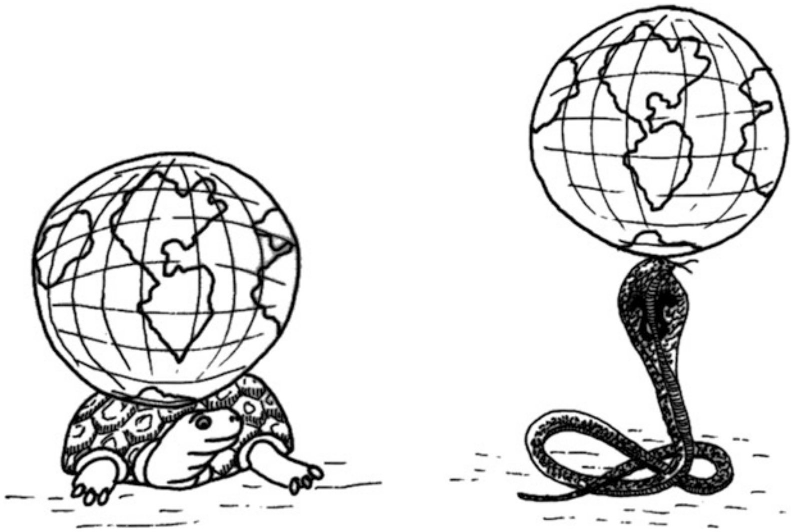


Fig. 4.1 It was once believed that Earth is supported either on the back of a giant turtle or on the head of a giant cobra and their movements explained the occurrences of earthquakes

There are numerous similar fascinating stories which were told and retold by our great grandmothers with minor variations here and there. In Japan, a giant catfish by the name Numazu was considered to be the creator of quakes. Those following the Bible thought, He looks over the Earth, and it trembles. So firm was the belief in the above words of Bible that these were engraved over the entrance to the western observatory of Boston College, Boston, by the side of the statue of Virgin Mary. In Hindu mythology also, there is a mention that mother Earth split open at the command of Sitaji, the wife of Lord Rama, so that she could enter into it.

In 350 BC, Greek philosopher Aristotle thought that earth shakes when wind blows through underground caves. Ovid, a Roman poet, believed that earthquakes occurred when Earth got too close to the mighty Sun which made it shake and tremble. Leonardo da Vinci (1500) believed that, "when mountains fall headlong over hollow places they shut in the air within their caverns, and this air, in order to escape, breaks through the earth, and so produce earthquakes."

Aren't they fascinating pages of human history against which we can judge the present level of progress? Modern science of seismology is sufficiently well advanced to provide clinching evidences and data that demolish the above myths and beliefs. The only paradox is that more we know about earthquakes, the greater is our ignorance.

Beliefs About Volcanoes

Many centuries ago, the people of island of Vulcano in the Mediterranean Sea believed that Vulcano was the chimney of the forge factory of the Roman God of Fire, Vulcan. Romans believed that Volcanoes occurred because of the hammering and forging works taking place within his deep underground forge factory in the womb of the mother Earth. Vulcan made metallic weapons and armor and whenever he got angry, he vented his anger through a puff of volcanic eruption. The God of Fire was named by Greeks as Volcan, Fig. 4.2.

In Hawaii, the belief was more or less the same but the creator of volcanoes named was different. Hawaiian legends named Pele, as the Goddess of Volcanoes. It was believed that the beautiful goddess lived in a crater at the summit of volcano Kilauea. She was both revered and feared and whenever volcanic eruptions occurred, these were taken as indications of her bouts of bursting anger.

Modern Volcanology is now advanced enough to set the myths at rest, and explain occurrences of volcanoes, scientifically.

Fig. 4.2 The eruption of volcanoes was attributed for centuries to the bursting anger of Vulcan, the Roman God of Fire

Beliefs About Lightning and Thunder

Lightning was regarded in Indian mythology as one of the mighty weapons of Lord Indra, the rain God. Even today, it would not be difficult to find people who continue to believe that lightning, thunder, rain, and storms occur at His will. The people of ancient China, likewise, regarded Sieou-wen-ing as the mother of lightning. Early Greeks believed that lightning was the creation of Greek God Zeus, Fig. 4.3. The Scandinavian mythology believed that God Thor thundered with lightning to silence his enemies. The holy Quran of Muslims says that "He it is Who showeth you lightning and launches the thunder bolts." The African tribesmen saw lightning as the act of their Bird-God. A similar belief existed in the Indian tribes of North America who thought that when a mystical bird ruffles its features, lightning is created, and its flapping wings create thunder. Interestingly, it is extraordinary that the locations hit by lightning, where great damage was done, were considered pious locations, best suited for erecting temples and other places of worship.

The beginning of the end of these beliefs was also the beginning of the science of lightning, the foundation of which was laid by Benjamin Franklin with his legendary kite experiment in 1752. The process of learning continues on and there is enough excitement left in the air to continue with our probe into the mysterious world of lightning for many more centuries.

Fig. 4.3 Early Greeks believed that lightning was the Greek God Zeus

Belief About Snow Avalanches

> For a long time people in Europe believed that avalanches were the doing of evil spirits; to them, the avalanche was what flies without wings, strikes without hands and sees without eyes- the avalanche beast.[1]

Magical Power of Beliefs: A Challenge to Science

History is witness that the magical power of belief in the supernatural has provided pabulum for further research, driving forward the wheels of science by several meters. Although many of the beliefs have proved to be mere passing clouds of smoke and myth but the fire of a few others still burns providing warmth to the men of faith and light to the men of science, for they must speak out to explain the facts which for now look stranger than fiction. The following example stands out:

[1] Sir Vivian Ernest Fuchs (1977).

Fig. 4.4 The above picture reproduced with permission from Dalada Maligawa temple at Kandy in Sri Lanka bears testimony to the grand Perahera organized by Sir Edward Barnes, the British colonial governor to end drought. The event was the rarest of rare spectacle of faith in the power of the tooth relic of Lord Buddha. The prayers were fully answered

Sri Lanka faced a severe, prolonged drought in 1829, the pain of which drove away all hopes of rain or reprieve. When all the doors appeared closed, the men of faith naturally turned to the grace of the tooth-relic of Lord Buddha and prayed for His blessings. Sir Edward Barnes, the British colonial governor spearheaded what is popularly called *Perahera* in order to invoke divine powers and bring to an end the severe drought, Fig. 4.4.

Buddha's tooth- relic rests in the Dalada Maligawa temple located in Kandy about 115 km away from Colombo (then Ceylon). The temple was built in 1595. Governor Barnes served Ceylon from 18 January 1824 to 13 October 1831 and it was in the year 1829 that he felt the intense heat of drought and the huge pressure of his administrative responsibility toward the drought affected population. With the exposition of the tooth-relic reportedly came the rain clouds virtually from nowhere and the ensuing down pour caused severe flooding. The statement engraved on a brass plate mounted on one of the walls of the Dalada Maligawa temple reads as follows:

> A prolonged drought was stopped by a special exposition of The Tooth Relic and the heavy rains resulting there from caused severe floods that were named Dalad Floods. Governor Edward Barns took a leading role to organize this exposition with pomp and glory.

The consequent rain was so heavy that the flood waters topped the Kandy Lake and inundated the low-lying areas. "Dalada Sirita", a highly revered Sinhalese book on Buddha's Tooth Relic states that, "when there is no rain, make offerings to the Tooth Relic in this manner."

Clash of Ignited Minds in the World of Beliefs

Our beliefs about divine intervention have crossed several transformational phases through the corridors of time generating both heat and light. One such phase was when some of the ignited minds in the recent history took diverse positions, as the following example from life and times of Mahatma Gandhi, Rabindranath Tagore, and Jawaharlal Nehru would convey. The example relates to the Bihar–Nepal earthquake of 1934.

Gandhi: In the Camp of Supernatural

Mahatma Gandhi, the greatest champion of nonviolence, firmly believed that disasters are the punishment of God for our sins. The following is what Mahatma Gandhi wrote in the aftermath of the great Bihar–Nepal earthquake of 15 January 1934 (see Footnote 1):

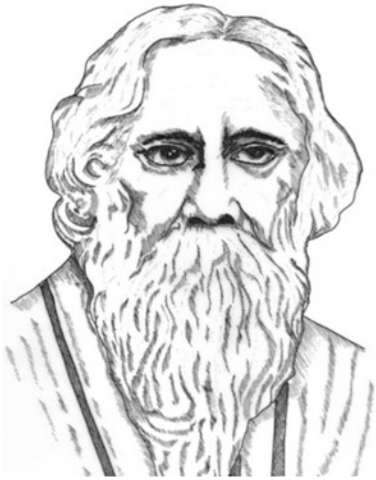
> For me, personally, this earthquake has a much deeper lesson than that it has brought physical ruin to thousands of homes. It is my firm conviction that such calamities descend upon mankind from time to time as a fit punishment for its sins. I love to think that it is a punishment awarded to us for the great sin of untouchability.

Mahatma Gandhi again spoke at a public meeting held in Tuticorin on 24 January 1934, attended by 25,000 people and the following is what he said:

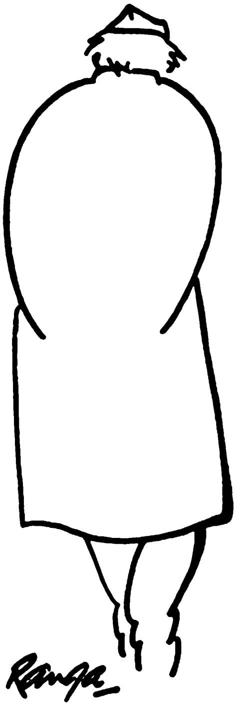
> Let us derive the lesson from this calamity that this earthly existence is no more permanent than that of the moths we see every night dancing round lights for a few minutes and then being destroyed. This earthly existence of ours is more brittle than the glass bangles that

ladies wear. You can keep glass bangles for thousands of years if you treasure them in a chest and let them remain untouched. But this earthly existence is so fickle that it may be wiped out in the twinkling of an eye. Therefore, whilst we may have yet breathing time, let us get rid of the distinction of high and low, purify our hearts, and be ready to face our Maker when an earthquake or some other natural calamity or death in the ordinary course overtakes us.

Tagore and Nehru: In the Camp of Science



Rabindranath Tagore, the great Indian poet fundamentally disagreed with Gandhiji on his views on the Bihar–Nepal earthquake. Tagore considered the views "*as unscientific and could see no connection between the earthquake and ethical failure*". He wrote, *"It is all the more unfortunate because this kind of unscientific view of a natural phenomenon is too readily accepted by a large section of our countrymen.*"



Pundit Jawaharlal Nehru joined Tagore in opposing Mahatma Gandhi's view. He raised several rhetorical questions like:

> If the earthquake was a divine punishment for sin, how are we to discover for which sin we are being punished? Why did not the earthquake visit the land of untouchability itself? Was it a judgment on the prevailing zamindari system since many rich land owners had suffered losses in the earthquake? Could the British rulers interpret it as a divine punishment because Bihar had been taking a leading role in the freedom movement? Since Nehru did not attempt to answer these questions, it is obvious that he had posed them just to indicate that Gandhi's logic was flawed or difficult to understand. Nehru concluded that it was astounding to suggest that human customs could cause movements in the earth's crust.

Endless Journey from Beliefs to the Basics

It takes ages to come out from the tunnel of darkness to the corridor of light passing through the world of knowledge. The darkness recedes and light becomes brighter as we move forward. The history of our understanding of natural hazards is written by generations of relentless effort in the pursuit of truth, and as the truth keep surfacing in the process, beliefs, and myths keep disappearing, Fig. 4.5.

We have left behind many beliefs and myths but our exploratory journey into the science of natural hazards has only begun with an ever receding goal post. The basics are becoming increasingly clear. As we probe deeper, the science advances and we get some answers and many more questions and so the journey goes on. It

Fig. 4.5 Students must be exposed to the science behind natural hazards and made to think for themselves so that they do not get swayed away by what others have said no matter how high or mighty

is by now increasing clear to us that "*Nature is an endless combination and repetition of a very few laws. She hums the old well-known air through innumerable variations.*"[2] Furthermore, we are convinced that, "*It is absolutely impossible to transcend the laws of nature*."[3] Those who once attributed natural

[2] Ralph Waldo Emerson, "History" in Essays (First Series 1841).

[3] Karl Marx, letter of 1868.

hazards to the anger of God are converts today because they see no difference whatsoever between God (Nature) and the unfolding truth. Thinkers like Voltaire gave a new twist to our pursuit of knowledge when he said that "*To believe in God is impossible-not to believe in Him is absurd.*"[4] The beautiful lines of Eucid: "*The laws of nature are but the mathematic thought of God*,"[5] came with a breeze of cool air, to which Vivian Fuchs (1977) added fragrance when he opined that "*….knowledge, howsoever incomplete, has removed the fears and superstitions with which primitive people invented the unknown.*"[6]

Shifting thoughts from the slumber of *myths* to the steep of *truth* behind natural hazards gained momentum as we began to see hazards like volcanoes, earthquakes, tsunamis, and landslides as *nature's safety valves* (and not God's anger) to *vent out* the internal pressures of the restless mother Earth, which is still evolving.

It is now an irrefutable fact that *we walk on the crust of an unfinished planet.*[7] In the words of George Pararas-Carayannis *Indeed, as a scientist I only evaluate the causes of natural disasters in terms of the forces of nature on our planet; forces such as tectonic interactions and earthquakes, tsunamis or the effect of incoming solar radiation on weather disaster. I do not view the disastrous effects of natural disasters on innocent people as deliberate "Act of God" but as manifestation of human failure by public officials in certain areas of the world to plan, prepare and adequately protect their people.*[8]

Centuries of experience has taught us to perceive the big picture, think to scale, and act in time. In the words of Marg de Villers:

> Our vulnerability to calamity is affected by the different time scales on which we and the planet operate. Humankind's entire existence has been a mere nothing in geological time-all the biographies of all Homosapiens are crammed into only a few millisecond as the cosmos reckons these things. If you look at it positively, the very existence and survival of our species is actually due to that great disparity, the gap between major disasters and the minuscule human life span. So when calamity comes, it has tended to come as a terrible surprise. So very long it has been since the last such calamity that memories have faded, perhaps altogether, perhaps transmuted into legend.[9]
>
> On human scale, we see the landscape and the geography of our planet as more or less permanent. We consider rocks to be inert elements about which, from time to time, we receive news of a landslide, an earthquake, or a volcanic eruption. The gradual elevation of a mountain range, the relentless erosion of surfaces, or the widening gap between the shores of an ocean necessarily go unnoticed, simply because they occur at a pace that only geological observation is capable of detecting. The formation of waterways requires tens

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[4] Voltaire.

[5] Eucid: Gudder (1976).

[6] Sir Vivian Ernest Fuchs (1977).

[7] Quotation by Charles Kuralt: "It takes an earthquake to remind us that we walk on the crust of an unfinished planet," CBS' TV magazine program "Sunday Morning" commenting on an earthquake in California.

[8] George Pararas-Carayannis, Former Director, International Tsunami Information Centre in Honolulu and a leading Tsunami Expert. (Quoted by Stern 2007).

[9] de Villers (2008), Chap. 2, p. 19.

> and even hundreds of years, glaciation thousands, continental drift millions, and the formation of the atmosphere, thousands of millions of years.[10]

The impressive outcome of our sweat and toil continues to fuel human curiosity. Every little thing we do aggregate to brighten our cosmic view. When the Gujarat earthquake of 2001 struck India, a layman out of sheer curiosity read to me a news item and asked—how did the Americans measured this earthquake sitting thousands of miles away? I very briefly recounted the steps. His next question was how deep could be an earthquake? It surprised him when I said that depth of an earthquake could be as great as 700 km which is much more than the distance between Ahmedabad and Mumbai. It was at that point on time that I realized why I myself had accepted what I had learnt without questioning? As a geotechnical engineer, I had learnt a lot about ductility of rocks on account of high confining pressures at great depths. The point of curiosity was the mechanism of a deep earthquake despite the state of ductility of the rock masses at great depths.

Let us take another example of a path-breaking contribution out of sheer curiosity. While studying earthquakes, Richard Dixon Oldham (1858–1936) was surprised when he could not detect primary earthquake waves at certain locations on Earth's surface. It was his curiosity which led to the grand visualization that planet Earth has *an inner core*. He thus gave a new meaning to the structure of the Earth yielding the following picture, which changed the world view.[11]

> Earth is like an avocado. The mantle is the edible flesh above the core. The crust might be the skin of the fruit. The motor of the Earth churns over the mantle; it is where mountains are born and the plates die. It is the deep unconscious of our planet, the hidden body whose bidding the continents obey.

Let us take the example of lightning:

> When Benjamin Franklin invented the lightning-rod, the clergy, both in England and America, with the enthusiastic support of George III, condemned it as an impious attempt to defeat the will of God. For, as all right-thinking people were aware, lightning is sent by God to punish impiety or some other grave sin—the virtuous are never struck by lightning. Therefore if God wants to strike any one, Benjamin Franklin [and his lightening-rod] ought not to defeat His design; indeed, to do so is helping criminals to escape.[12]

Imagine what a setback it would have meant to our understanding of the history of lightning as a natural hazard if Benjamin Franklin would not have done what he did to unravel the mysteries of lightning. Whenever we are hit by lightning and thunder storms, ordinary mortals are seen running indoors for their lives until the calm returns. Very few among us have the grit, courage, and curiosity of doing exactly the opposite without any fear of personal safety. Today we know so much more about thunderstorms, and for that matter about other hazards, not because people ran indoors to protect themselves and watch the drama outside from the

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[10] Press and Siever (2001).

[11] de Villers (2008).

[12] Russell (1943).

slits of windows but because of the people who fearlessly chased the storms to unravel their secrets and to add a few more bricks to the edifice of knowledge.

In the words of Thomas P Grazulis[13]:

> Storm chasing can be a religious experience-the power of the creator revealed in the spectacle of the thunderstorm. Chasing can be a cosmic experience, with the primal forces of the universe on display right here on earth. There is no need to imagine the energy in a supernova or a comet collision on Jupiter. Nature is truly up close and personal, especially when a 30-million-volt lightning bolt hits just a few yards away. For a few fortunate scientists, it is an opportunity to explore one of the last frontiers, the interior of a super cell thunderstorm. The number of storm chasers has been steadily on the rise signaling more exciting scientific discoveries in the future.

Science has left no room to doubt that natural hazards like earthquakes volcanoes, lightning, and cyclones may be the acts of Nature but the disasters they cause are of our own making. According to a World Bank Independent Evaluation group Report on Hazards of Nature, risk to development published in 2006: "*Natural Disasters are nature's judgment on what humans have wrought*".

This is also what most teachers teach their students in a class room but they may now have to do it more forcefully. That would naturally happen when teachers believe in what they teach. The visible disconnect between the belief and the spoken word seems to persist which is why there is confusion and absence of clarity. It is often easy to market faith than to market science outside the class room. The faith in science is indeed the hardest thing to market particularly when the sky overhead is cast with clouds of an impending disaster. Is it not a fact that even hard core scientists, while in the thick of a disaster, tend to think of *supernatural* first and *science* afterward? It is apt to recall Hunter S. Thompson suggests that by all means "*Call on God, but row away from rocks*".

Disasters affect nearly half of the world population casting shadow of threat on the other half. And threats of disasters continue to be increasing especially due to climate change (Fig. 4.6), deforestation (Fig. 4.7), and urbanization, Fig. 4.8. By 2025, disasters are likely to unnerve nearly 80 % of the world population in the developing world. It is here that the exploding population, mindless violence against nature including deforestation, resource crunch, ongoing chaotic development, vulnerable stock of squatter settlements, and the curse of huge governance deficit will combine to test human endurance to its limits. Since there is no way additional land could be produced to meet the already explosive population demands, people will continue to migrate and build on floodplains, wet lands, low-lying areas, unstable slopes, and reclaimed lands. The dynamic nature of urbanization and the pain of the past baggage of problems leave us with little choice other than to ensure that disaster management is integrated with the development planning process so as to create disaster resilient societies and cities, Figs. 4.9, 4.10, and 4.11.

[13] Grazulis (2001).

Fig. 4.6 While the humankind is fighting the devil within itself to save the mother Earth from extinction, the devil of climate change is fueling the fire. Climate change will choreograph what President Obama called Natural Man-made Disasters

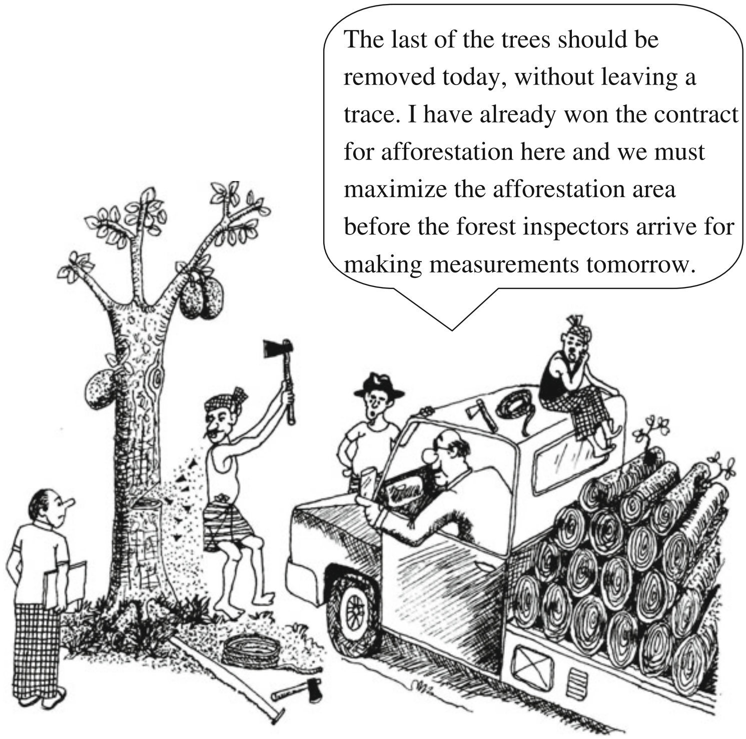


Fig. 4.7 Deforestation of our lands for urbanization, building construction, agriculture, and grazing has been the main cause of environmental degradation. Afforestation programs are being undertaken the world over to reverse the trend. Our ultimate success would, however, depend on the change of the old mindsets responsible for the current alarming situation

Fig. 4.8 Exploding population and mindless urbanization have caused a great pressure on our lands. Protection of environment should be on the top of our development agenda

Fig. 4.9 "The environment friendly". *Cartoon courtesy* Arun Inamdar, in Salt'n Pepper reproduced with permission

Fig. 4.10 Celebration of World Environment Day on 5th of June every year should awaken us to the reality that "when all human drama is over, Nature will speak the last word. And there will be no one at home to shed tears for the last man" Quotation: Carlos and Rashmi (2001)

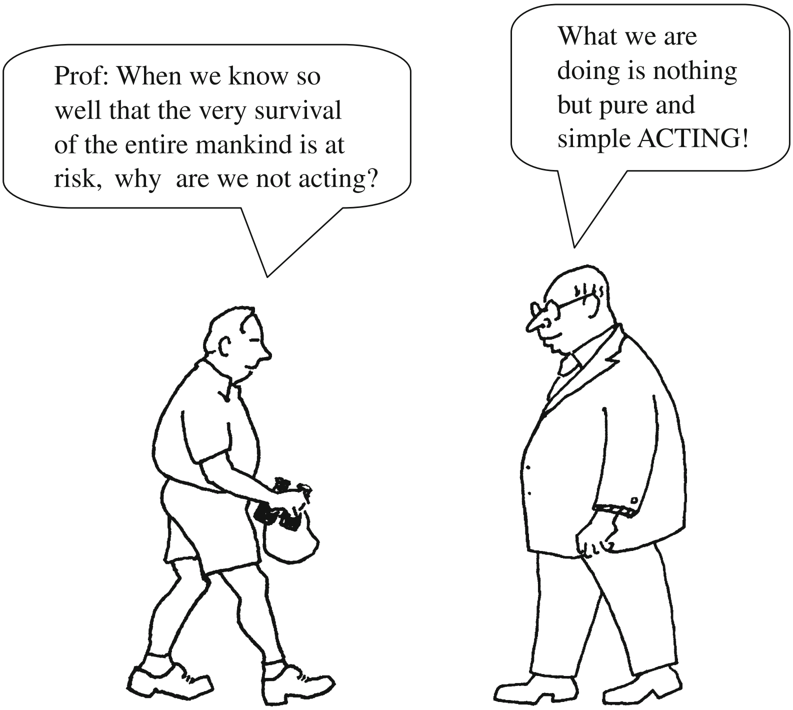
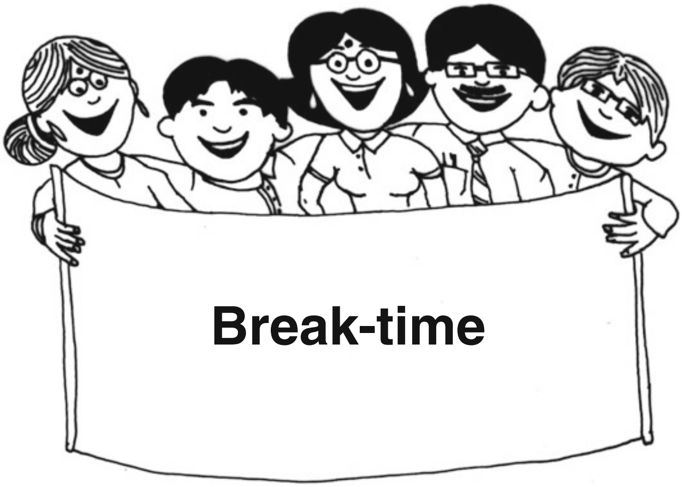


Fig. 4.11 There is a difference between activities and achievements. A litany of activities may not automatically translate into achievements without focus on clear goals and the matching commitment. The hiatus between our scientific and operating tempers and the disconnect between our speech and action stand between our actions and achievements



Break-time Question 14: Give one example of some old belief interpreted in the light of modern science?

Answer to Break-time Question 14

There are many countries in the world in which people seek protection of God against wrath of disasters by erecting temples, mosques, and churches at disaster prone sites. During the Orissa super-cyclone of 29–30 October 1998 in India, in the campus of Regional Research Laboratory of the Council of Scientific and Industrial Research at Bhubaneswar, hundreds of trees including a huge Banyan tree fell to the super cyclone. This created big news because another Banyan tree in the same campus blessed with the Trishul of Lord Shiva had survived the fierce winds of the super-cyclone. These observations were at once connected with the other incoming news that Orissa super-cyclone has also spared some of the most famous temples of Orissa. A post-disaster investigation revealed that the banyan tree that had survived the winds was because of the circular, solid concrete platform around the tree which had opposed the cyclonic winds and the torque. The presence of the circular platform altered the aerodynamics of the flow of wind around it, besides providing much larger base area to take care of the base moments, shear forces, and uplift.

The practice of erecting temples for protection against impending dangers is seen in many countries of the world, Fig. 4.12. A kovil (temple) existed on a 100-year old-Watawala landslide in Sri Lanka, right above the threatened stretch of the railway line. Indeed the kovil survived for many months amidst the widespread subsidence of the adjoining areas but it eventually had to go down the slope.

It is a common knowledge that wind forces on a structure depend on wind velocity, shape, and surface of the structure, and neighborhood topography. Flowing wind produces pressure on the windward side and creates suction effect on the leeward side resulting in unsymmetrical flow, drag forces, and uplift. Other

Fig. 4.12 The above picture shows a temple built on a platform surrounding a tree in a landslide-prone area in Sri Lanka. Such practice of seeking protection of a deity to keep away disasters is common in many parts of the world including India

things remaining equal, circular-shaped structures are able to withstand higher force of wind. This was the reason why the Orissa super-cyclone did no damage to the tenth century Parasar temple of Paradip, the twelfth century Madhavananda temple, the Lataharan temple, and the eleventh century Jagannath Puri temple of the coastal town of Orissa. Consult a structural engineer to understand more about the building design features and shape effects.

Similarly, once it was reported that in a great majority of cases, major earthquakes in India struck between 7.30 p.m. and 6.30 a.m. of the Indian Standards Time. It will not be difficult to assemble statistics that might confirm that the opposite is as true.

There are also stray observations which suggest that earthquakes generally occur 1 or 2 days before or 1 or 2 days after an eclipse and on new moon and full moon days. The great Kangra earthquake of 4th April, 1905, the Quetta earthquake of 13th May, 1935, and the Assam earthquake of 15 August 1950 all happened on the new moon day. Murthy (1993)[14] quotes Raman (1981) having predicted the solar eclipse of 31st July, 1981 and also predicted the powerful earthquake in Iran and Turkey,

[14] Murthy (1993).

which reportedly came true. He had also predicted occurrence of earthquakes in Turkey, Mexico, Iran, Japan, and Western Asia based on movement of Jupiter into the zodiac arc of Libra, particularly traversing the arc of Chitta constellation. All this needs to be studied in greater detail. In science, all observations are welcome but only those which stand rigors of scientific scrutiny gets acceptance.

There is also a tendency to mislead people by reeling out selected statistics and numbers that convey a sensational thought. For example, a case was made out to demonstrate how deadly figure 8 could be, as seen in the following table. It is easy to demolish such prepositions through unbiased analysis of data.

Does Earthquake Favor Numeral 8?

A day after the Muzzafarabad earthquake of 2005, the Asian Age reported statistics to suggest a connection between earthquakes and numeral.

Earthquake	Date	Magic number	Magnitude	Deaths
Muzzafarabad earthquake	8 October 2005	Eight	M 7.5	
Gujarat earthquake	26 January 2001	2 + 6 = Eight	M 6.9	20,000
Andaman Islands	26 December 2004	2 + 6 = Eight	M 8.9	200,000
Andaman Islands	26 June 1941	2 + 6 = Eight	M 8.1	
Shrimanagal, Assam	8 July 1980	Eight	M 7.6	

The following statistics convey exactly the opposite making numeral 8 as a blessed number.

Earthquake	Date	Magic number	Magnitude	Deaths
Shaanxi Province, China	23 January 1556	2 + 3 = Five	M 7.9	830,000
Lisbon Earthquake	1 November 1755	1 = One	M 8.5	50,000
Assam Earthquake	12 June 1897	1 + 2 = Three	M 8.1	1,500
San Francisco Earthquake	18 April 1906	1 + 8 = Nine	M 8.3	700
Kwanto Earthquake	1 September 1923	1 = One		143,000
Alaska Earthquake	27 March 1964	2 + 7 = Nine	M = 9.2	140
Tangshan Earthquake	28 July 1976	2 + 8 = Ten	M 8.0	250,000
Kangra Earthquake	4 April 1905	4 = Four	M = 8.5	30,000
Bihar Nepal Earthquake	15 January 1934	1 + 5 = Six	M 8.1	10,700
Chilean Earthquake	25 January 1939	2 + 5 = Seven	M 8.3	28,000

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The New Awakening

5

Abstract

We live in a global village and therefore disasters, regardless of wherever they occur, affect us all. The war against disasters is, therefore, being fought unitedly with synergy of strengths and with the big global picture in mind. The hazards may be natural or man-made but disasters are increasingly being attributed to anthropogenic factors. The time has come to remove the causative factors and shift the focus from single to multiple hazards; from concerns of safety to the culture of safety; from relief-centric approach to disaster mitigation; from use of primitive technologies to adoption of innovative, modern technologies; and from search for piecemeal solutions to the quest for lasting remedies. The chapter throws light on the current global thinking on disaster risk reduction and familiarizes the reader with some of the landmark global initiatives of far reaching impact.

Contents

R. K. Bhandari, *Disaster Education and Management*,
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Big Picture

The world has now shrunk to the size of a global village and disasters striking around the globe whether in Asia, Africa, Oceania, or elsewhere are no longer unconnected in our thought, speech, and action. Every square inch of mother Earth is vulnerable to disasters of one kind or the other and disaster risk reduction and management strategies may really mean nothing without visualizing and then constructing the big picture first. Disasters often take heavy toll of life and property and derail national economies. In some cases, they even erase several pages of glorious human history and trample over the future of generations still unborn. The visualization of the big picture alone can help us in preventing disasters and where unavoidable, convert them into opportunities and pursue those opportunities through local and global synergistic imagination and initiatives.

For centuries, the horrors of natural disasters continue to haunt the humankind and their painful tales either die with the dead or remain alive through eyewitnesses and lucky survivors, Fig. 5.1. We, by now, have plenty of captivating stories and heart-rending statistics on disasters. According to Cornell 1982[1]: "*the number killed by individual events may approach- earthquake (2 million), cyclone (300,000), landslide (100,000), tsunami (100,000), volcano (30,000 immediate deaths, 92,000 immediate plus secondary deaths), and avalanche (20,000).*"

Also by now, we understand the various types of disasters and their risk potential better than ever before. Our disaster management skills have also grown with the passage of time and experience. However, the daunting challenge we continue to face lies in coming to terms with the complexity of disasters and the mind boggling energy with which they hit. The kinetic energies in ergs unleashed by different natural hazards like tornado (10^{21}), thunderstorm (10^{22}), severe cyclone (10^{26}), and earthquake (10^{10} to 10^{25}) are too formidable to be managed. We fear an atom bomb more than we fear an earthquake because we do not realize that the energy levels of an atom bomb of 20,000 tons of TNT and those of an earthquake of magnitude 6 are the same. If and when we will get struck by an earthquake of magnitude 8, we will be required to deal with the energy levels of a 50 megaton hydrogen bomb. The challenge before us is, therefore, to diffuse such orders of disorderly energy without getting a scratch on our skins.

[1] In Encyclopedia Britannica, 15th edition.

The big picture of disaster scenarios in a given case alters a great deal when a disaster triggers a chain of secondary disasters, and when disasters transcend national boundaries. For example, the Indian Ocean tsunami of December 2004 struck many countries simultaneously. Originally, it was seen as merely as an isolated underwater earthquake off the coast of Sumatra until triggered a tsunami which rattled the whole world. The context in which world viewed the aftermath of the tsunami got completely changed as the big picture began to emerge.

Growing Awareness About the Darkening Clouds of Danger

The world is becoming increasingly more unsafe with the influx of many new, relatively less understood causative factors such as the climate change. Although no more proof is needed to conclude that disasters of the future will invariably carry the signature of climate change, our strategy to deal with the ensuing challenges is still evolving. It is apt to quote Barrack Hussein Obama, the 44th President of the United States of America who underscored that "all across the world, in every kind of environment and region known to man, increasingly dangerous weather patterns and devastating storms are abruptly putting an end to the long running debate over whether or not climate change is real. Not only it is real, it is here, and its effects are giving rise to a frighteningly new global phenomenon; the man-made natural disasters."

According to UNEP Executive Director Achim Steiner, *"the invoice of our climate changing emissions will include more droughts, floods and other natural disasters."*

Broadly speaking, we are already being enveloped by the rising temperatures, attacked by more intense heat and cold waves, and threatened by exceptional winds, droughts, and floods. When the year 1998 was declared as the warmest year in the 1,200 years history, we were also told that the worst is still to come. The temperatures of the oceans are really rising signaling deadlier hurricanes. According to one estimate, the typhoon breeding areas have increased by over 16 % during the last 20 years. If our business continues as usual and the greenhouse effect compounds, the global rise of temperature may lead to alarming sea level changes exposing the small island States to submergence and displacing populations.

As the trends go, the tropical storms will probably extend toward Poles, more water vapor will mean heavier rainfall, more floods, and greater number of thunderstorms and tornadoes. The coastal regions will see far more storm surges, particularly where a rise in sea level and a higher frequency of storms coincide. And there could also be frequent and serious droughts, with increase of El Niño strikes.

Overall implications of climate change are going to be far more serious than we realize. For instance, the secondary effects of climate change will give fillip to avalanches, landslides, rockfalls, and other mass movements. Areas deficient in rainfall will face droughts more frequently and in the areas of drought, forest fires will fan the damage. With the rise in temperature and melting of glaciers, we will see more of Glacial Lakes and Glacial Lake Outburst Floods.

According to Michael Jarraud "about 90 per cent of all natural disasters are disasters of meteorological and hydrological origin. The World Meteorological Organization aims to halve the number of deaths due to water related disasters over the next fifteen years, by improving alerting systems for weather and water events through risk assessment, hazard detection, awareness raising and education about disaster prevention of communities at risk; capacity building in developing countries; and the allotment of a portion of development assistance to disaster prevention strategies."[2]

Since the effect of climate change will hurt us both in the short and the long-term, our strategy to fight climate change cannot stop at finding quick fix kind of solutions merely to the present day problems. The short-term concerns about rising temperatures, melting glaciers, increasing rainfall events, and flooding may too have long-term implications. For instance, rising trend of seawater levels is nothing short of an early warning to the possible submergence of island states threatening the very survival of millions living there.

Disaster Risk Reduction: A Stimulus to the Economy

Disasters are known to erase years of development and crumble national economies. Disaster risk reduction, besides reducing losses, serves as an economy booster. According to a United Nations and World Bank joint publication, in a 40-year period between 1970 and 2010, earthquakes, hurricanes, and other hazards killed nearly 3.3 million people. This does not include traffic accidents which take a huge toll of 1.27 million lives annually. Of all the disasters, drought is the deadliest. Although both rich and poor countries are exposed to hazards, most of 3.3 million people killed in the last 40 years have been from the poor countries. The data on property damage are reportedly less comprehensive than statistics on deaths. According to one estimate, disasters caused property damage to the tune of $2,300 billion during 1970–2008, at 2008 rates. The estimates of indirect losses are generally calculated only on a case to case basis.

It is for this reason that disaster risk reduction lies at the heart of the disaster management plans and every effort is made to integrate disaster management with the development planning.

[2] Michael Jarraud, Secretary General of the WMO. (Excerpt from his statement at the World Conference on Disaster Reduction in 2005.)

Managing the Added Pain of Man-Made Disasters

Natural hazards often turn into disasters because of human greed, violence, and human failures for which nature unfairly gets the blame. There are disasters which are entirely man-made, Fig. 5.2. A quick glance at the global scenario will show that the ugly scars of disasters which wrecked Hiroshima, Nagasaki, Bhopal, Chernobyl, and the Exxon Valdez are permanently engraved in our minds and pain caused by them still persists. A disaster striking in the form of terrorism is even more serious because it threatens life 24 $\times$ 7, drains scarce resources, and strains national disaster management capacity. The horrendous tales of what happened in New York on 9/11, in Mumbai on 26/11, and at the UN Headquarter in Baghdad on 19 August 2003 (Figs. 5.3 and 5.4) are some of the speaking examples. Imagine if terrorists were to strike us while we are already in the vortex of a natural disaster or if the victims of a natural disaster are additionally exposed to loot while already in the state of pain. We too need to introspect on the validity and effectiveness of our actions, Fig. 5.5.

Unchecked urbanization is a matter of grave concern. Additionally, the population time bomb is ticking continuously every minute of the day. We already have as many as 20 mega cities with more than 10 million population; in addition, of course to as many as 60 cities with population exceeding 5 million. An estimated 7.5 million children are born every month which, in a sense we add a mega city to the world population every year. And in many developing countries, characterized by heavy concentration of population, shanty towns, slums, and marginal settlements, a disaster can lead to grave consequences even where the initial impact of the disaster may not be very severe. The most common of such repercussions of disasters are characterized by, for example, cyclone-flood contamination-epidemics, and rainstorm-flood contamination-epidemics. It is this possibility of a chain reaction that needs to be effectively addressed.

We learn the most when we ourselves experience a disaster and are an alert eye-witness to it. It is increasingly being realized that the eye-witness accounts lie at the heart of scientific studies on disasters. An alert eye-witness can easily transmit images through mobile phones.

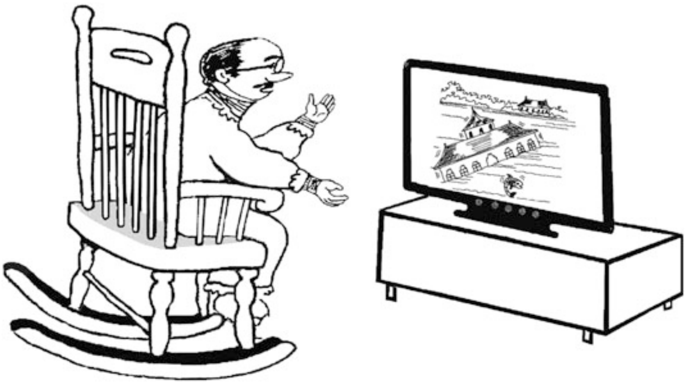


Fig. 5.1 There is a difference between terms 'Eye-witness' in the above picture and 'I–witness' in this picture. Because of the magical power of television media, today thousands of people are I–witness to the very same event as seen by an on-the-spot eye-witness at the site. Modern technology makes it possible to take a tour of a disaster as it develops through real time telecast

The Concept of Total Safety

Disaster management traditionally aims at management of individual hazards but in the real life situations people in a given area face different hazards at different times or several hazards, one triggering the other, at the same time. Safety against every individual hazard is therefore important but what really matters is the total safety regardless of the type, scale, manner and mood of disasters, and the swiftness and timings they choose to strike. An overview of multiple hazards is given in Fig. 5.6. Our capacity to comprehend hazards we face is extremely limited which is why very often we are confronted with the situations we had never anticipated.

We continue to prepare separate plans to manage disasters due to earthquakes, landslides, tsunamis, and other hazards but our plans will yield the best results only when the separate plans get integrated into a single strategic plan for a coordinated action. For example, an underwater earthquake can create a tsunami which may in turn cause severe flooding and an epidemic. Similarly, a Glacial Outburst Landslide Floods (GLOF) can cause inundation which may then lead to deaths by drowning and epidemics. It is also possible that two totally unconnected hazards, for example, a tornado and an earthquake occur in league about the same time. Many areas are visited by different types of hazards at different times. It follows, therefore, that our ultimate safety would depend on our mega view of both multihazards and multiple hazards and our degree of preparedness to face these, if and when they occur.

Fig. 5.2 Man-made disasters are avoidable if we give-up mistrust, violence, greed, and immoral practices. The above figure shows an outstanding example of disasters resulting from mistrust. *Source* India today of 6 March by Ravi Shankar

Whereas the plans for fighting individual hazards will continue to have relevance and popularity because of the convenience in visualization of the hazard-centric disaster scenarios, limitations of existing single hazard mitigation will continue to hurt until we remedy the situation. We need multihazard maps and a logical and easy-to-handle operational mechanism anchored to a well-considered holistic plan.

Another point often forgotten is the speeds with which various disasters strikes. Unlike earthquakes, tsunami, and cyclones, disasters due to droughts, famines, desertification, and epidemics come slowly allowing us sufficient time to act.

Fig. 5.3 The UN building in Baghdad before the terrorist bombing of 19 August 2003 in which 19 United Nations staff including the special representative of the U.N. Secretary General were killed. The author was a member of the UN team in Iraq at that time

Fig. 5.4 The view of the U.N. building (popularly known as the Canal Hotel) after terrorist bombing on 19 August 2003

Security Forces bombing the terrorists

Terrorists bombing the Security Forces

Fig. 5.5 Bombing and violence are bad regardless of the justification or absence of it. Always remember that violence breeds violence

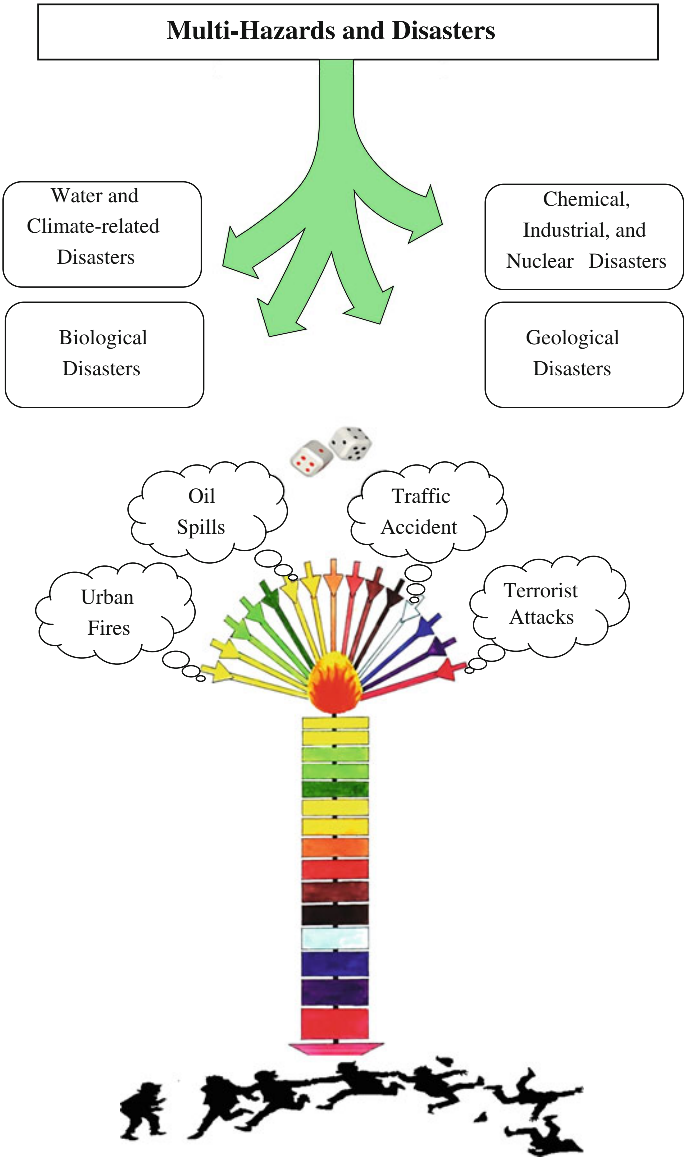


Fig. 5.6 We need to talk of total safety against multiple hazards

Test of Preparedness: A Nail-Biting Example

Comprehension and projection of possible disaster scenarios will be of little use unless matched by adequate preparedness to deal with those scenarios. The story of the Great Kanto Earthquake of 1923 which unleashed Fire, Tsunami, Typhoon, and Landslides, all in a very strange click, reminds us that even with the best of efforts, we may miss out the worst disaster scenario. By hind sight, it appears to be a nail-biting thriller, bizarre in appearance, and formidable in consequence.

It was the first day of September and the time was fifty-eight minutes past eleven in the morning. An earthquake of magnitude 8.3 shook the whole of Kanto region devastating the cities of Tokyo, Yokohama, Chiba, Kanagawa, and Shizuoka in Japan.

The earthquake triggered fires, which took a toll of 140,000 lives with as many injured. The small fires joined together to generate what we recall as the Great Tokyo fire of 1923. People at lunch, cooking on stoves using wood as fuel, saw the toppling of stoves fueling the fire.

In the meantime, a severe typhoon struck the coast of Noto Peninsula in the Northern Japan to join hands with the earthquake and the fire. Its winds not only fanned the fire but made it big enough to engulf a number of cities. As if all this was not enough, a tsunami wave, as high as 10 m, closely followed the typhoon, at the coast of Sagami Bay, which happens to be the epicentral region of the Boso and Izu peninsula.

While all this was happening as catenation of events, knocks of earthquake after shocks provoked landslides which eventually hit the hilly coastal areas in Kanagawa Prefecture and the neighboring mountainous areas.

The earthquake, the fire, the typhoon, the tsunami, and the landslides took a toll of nearly 1,42,800 lives, according to a United States Geological Survey estimate. It was difficult to separate out deaths due to the earthquake and fire but fire was rated as the biggest killer. In a single place at Rikugun Honjo Hifukusho in Tokyo, as many as 38,000 people were burnt alive. The landslides killed about 800 people of which 100 were passengers in a stationary train at Nebukawa that slid with the slope. The tsunami killed about 100 additionally.

The moral of this story is that the sky is the limit which our state of preparedness must endeavor to cross.

From Problem Solving to the Culture of Safety

Whenever disasters struck us in the past, we struggled to fight them out with whatever tool we had at our disposal. Consequences of disasters were invariably grave especially when we faced them poorly prepared, without learning from the earlier disasters, and without proactive initiatives to prevent further disasters. Quick fix kind of solutions involving palliative measures gave us a false sense of safety and hope. Over and over again, we were caught napping because disasters turned

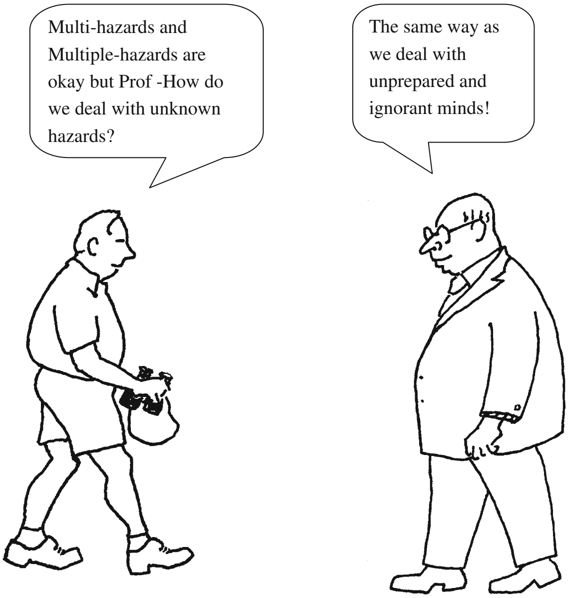


Fig. 5.7 Unforeseen and unknown hazards are more a reflection of our ignorance and lack of effort in mapping hazards rather than tables to hide under. We need greater imagination to be able to unmask the so called unforeseen and unknown hazards

out to be unforeseen, different, and beyond our capacity to manage, Fig. 5.7. We continued to make investments in managing individual hazards without adequate realization that several hazards can strike us in curious combination and their effective management needs a comprehensive approach. And that approach is to make safety a way of life rather than merely tackling disasters as and when they occur. The focus is therefore slowly but surely shifting from the limited objective of problem solving to establishing the culture of safety. And the culture of safety can take roots only when we nurture the culture of strategic planning, the culture of prevention and preparedness, and the culture of quick response as a matter of routine. Once we succeed in establishing and believing in the culture of safety, we will no longer need to plead for strong political will, allocation of resources, respect for Nature, mobilization, training and empowerment of local governments and communities, and tapping of appropriate technologies.

The Disaster Safety is the child of strategic thinking and disaster preparedness. It is useful to remember that disaster management strategies cannot be based on the disaster trends of a decade or two, no matter how clear and definitive. A decade or even a dozen decennia provide no more than a pin hole for us to observe the acts of nature which are always aimed at restoring balance amidst disturbance and chaos we create.

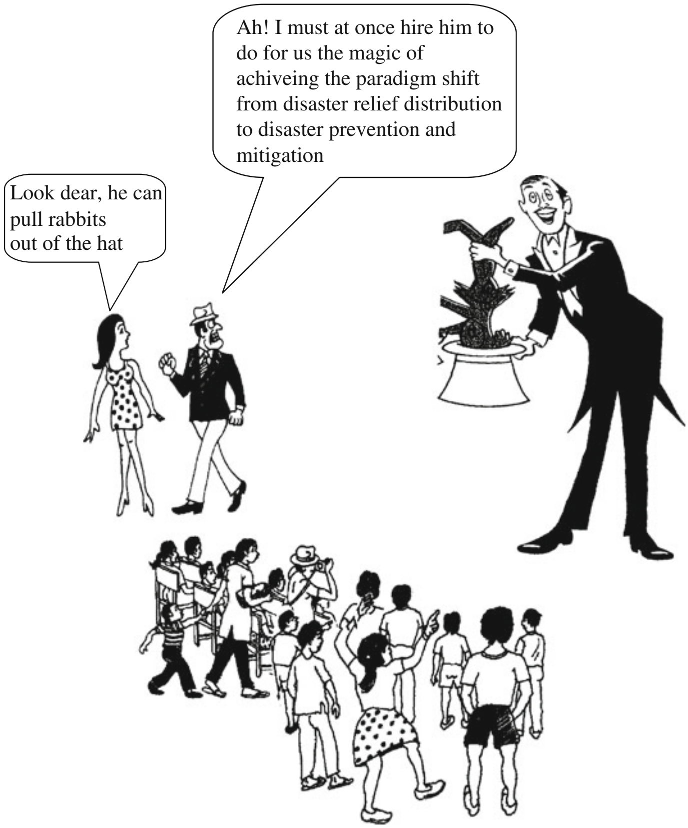


Fig. 5.8 Paradigm shift from the relief-centric approach to disaster prevention and safety is not going to be any easier than pulling a rabbit out-of-the-hat. The cherished aim of achieving the paradigm shift has become an oft-repeated slogan for public speeches without the realization that the journey has hardly begun and that there are no short cuts to the destination

From Relief-Centric Approach to Mitigation

The current approach of rushing to rescue and of taking recourse to relief distribution, reconstruction, and rehabilitation as a strategy for disaster management is out moded. We need a paradigm shift in our relief-centric approach to disaster prevention and disaster mitigation, Fig. 5.8. We need to change old mindsets of looking for end-of-the pipe solutions to finding lasting solution through proactive approach. We also need to ensure that what is urgent in our actions does not drive out what is important, Fig. 5.9. As Kofi Annan, the former U.N. Secretary General said, “Building culture of prevention is not easy. While the cost of prevention has to be paid in the present, its benefits lie in the distant future. Moreover, the benefits are not tangible; they are disasters that did not happen,” Fig. 5.10.

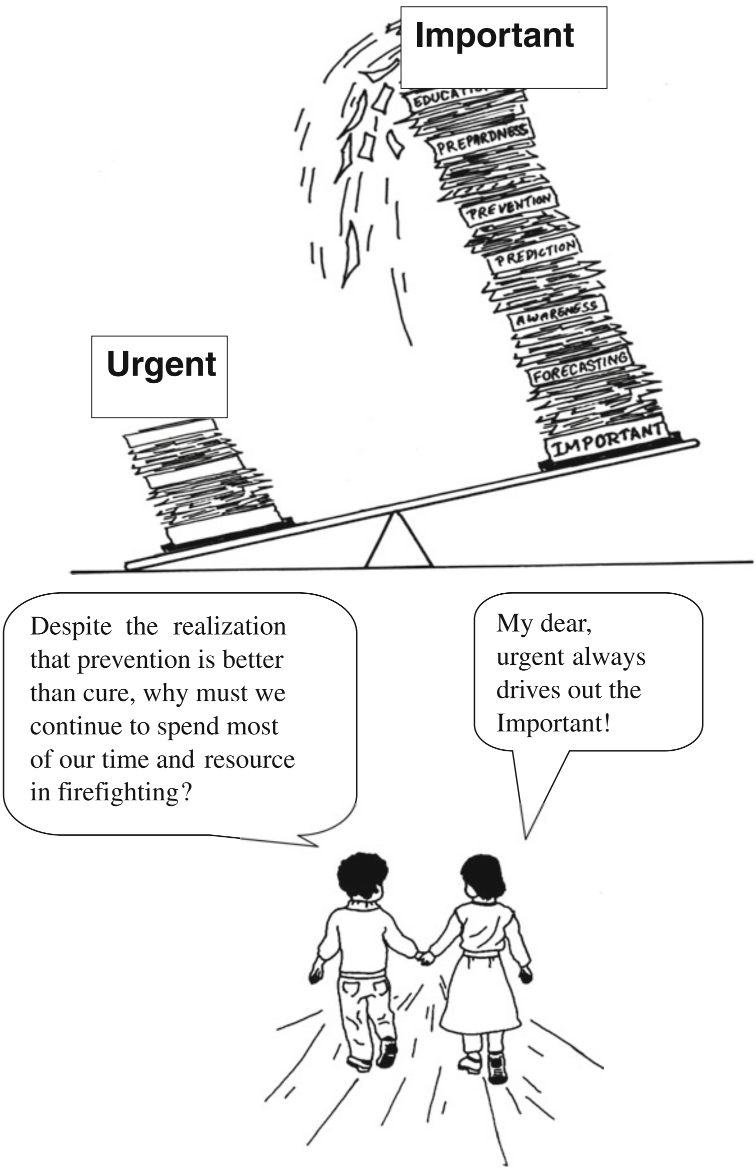


Fig. 5.9 Emergency response is urgent and therefore it drives disaster management agenda. Disaster prevention, preparedness, capacity building, disaster education, training, prediction, and early warning, are important but keep waiting for the emergencies to be over. We need both short- and long-term plans and strong commitment to focus on the important while we attend to the urgent

There was a time when disasters captured attention only during the periods of pain and were dealt with keeping only short-term public anguish in view. This situation changed to greater awakening toward prevention and mitigation as

Fig. 5.10 Who says disaster prevention is not possible? Ladies and gentlemen, this year's gold medal goes to Mr. Amol Mendonca for his work on disasters that did not happen

reflected in the political speeches, meetings, workshops, symposia, and conferences. The desired outcome, however, continued to elude us because political statements, allocation of funds, sporadic capacity building activities, and conferences lacked punch and power to change the old mindsets. Today, new institutions are in place to constantly remind us that the much sought-after paradigm shift in our approach to disaster mitigation is most essential and the success of our effort should be monitored in terms of disasters prevented, lives saved, communities empowered, causes of potential threats removed, and such other factors of achievement. We need a change of mindset, a strong political will, adequate allocation of resources, a firm commitment to the cause, and action beyond words right up to the finish line.

Experience has taught us that hazards like earthquakes, volcanoes, and landslides do not cause disasters in wilderness. Earthquakes cause disasters when our poorly built houses collapse and kill us. Volcanoes harm people who live too close to the active volcanoes. Landslides wipeout human settlements when people build even on problematic slopes visibly unsafe. In other words, hazardous events may become calamitous only when they hit the unprepared and vulnerable communities. With paradigm shift, our focus would change from prescription to prevention and from a piecemeal reactive approach to a people-centric, proactive holistic approach.

From Primitive to Modern Technologies

It is painful to see continued use of primitive technologies in this age of innovation and technology, Fig. 5.11. The best results can be achieved by blending richness of the traditional time-tested technologies with the innovation in the modern technologies. We need to ensure easy access to modern technologies, which are appropriate, affordable, and speed effective.

Today, we find ourselves fully surrounded by powerful technologies. More than half a century ago, Arthur C. Clarke said that "*any sufficiently advanced technology is undistinguishable from magic*." We have entered the twenry-first century with much more science and technology than we ever had in the entire human history. Decades ago, IBM's 'deep blue' defeated the Chess Grandmaster Garry Kasporov heralding the victory of machine over mind. Years ago, a $30 Furby Toy that talked to humans had more electronics in it than the first lunar module had when it landed on the surface of the Moon. Indeed, today's technology is like magic and can serve as a game changer in our war against disasters.

Let us take a couple of application areas that serve as examples of a quantum leap achieved through the unprecedented power of modern technology. There was a time when the news of a disaster, especially in a remote area, took weeks, and days to arrive. Today, the news of a disaster spread across the globe simultaneously as the disaster unfolds. Also, our emergency response is becoming swift and far more effective, Fig. 5.12.

Another technology simplified application area of profound practical impact is GIS mapping and assessments of hazards, vulnerabilities, and risks. The grammar of spatial, aerial, land, and submarine mapping has changed beyond recognition. There was a time when we had relied on rather crude, time consuming, and open-ended methods of hazard mapping, Fig. 5.13. Whatever was predicted by analyses had to be accepted as true. We had no easy way to validate the hazards maps against field observations. Today, we can map the outer space, air, land, and water to the accuracy we desire. Modern technology makes it possible update maps with influx of new data at the click of mouse. For us to be able to sense trouble, foremost of all, we need to have reliable knowledge of the level of hazard we face

Fig. 5.11 The difference between the Victorian and the modern technology is like the difference in the heights of the lady and the gentleman. Those still unattracted to the power of modern technology is prisoners of their old mindsets, ignorant of the benefits

and of our exposure (vulnerability) to that hazard. Once hazard and vulnerability are known in a given case, the product of the two will give us the sense of risk in any given case. By knowing the risk, we then proceed to arrive at suitable risk reduction strategies and corresponding disaster response plans.

We have technology to chase fiercest of the tornados. We have powerful ground penetrating radars, which X-ray ground with the same ease as the doctors X-ray a human body. The GPS has made a huge difference in locating hot spots across the

Fig. 5.12 Efficient use of Information Communication Technologies can work wonders and put us streets ahead in crisis management. It is important that we reap the fullest benefits of the power of technology

globe. There are powerful sensors which record smallest of the changes and transmit the data to any distance in real time. The underwater vehicles available today, effortlessly map the mysteries of hazards in deep seas, to depths as great as 6,000 m. There are observatories at altitudes as high as 5,000 m. The technology is changing as I write. We have already left behind the age of teraflop machines and computational skill is at its peak.

We need to take full advantage of the modern technology in carrying out detailed surveys, speedy investigations, purpose-based instrumentation and monitoring, real-time data processing, and in the field validation of hazard maps. Robotic machines can reach where we find it too risky to go. Why we have not

Fig. 5.13 Modern technology has made it possible to process, analyze, and integrate large volumes of disaster related data on a GIS platform and produce reliable hazard maps. There are enough papers and manuals written on the subject. It is now time to act

succeeded so far in adapting to new technologies is only because of our lack of will and human failure.

From Piecemeal Effort to United Global Effort

The huge challenge of securing safety against disasters requires that the whole world gets united in war against disasters. The following landmark events demonstrate that this is happening but a lot more is required because the war has just begun. Figure 5.14 gives a glimpse of the milestones laid on the road to destination disaster-free world.

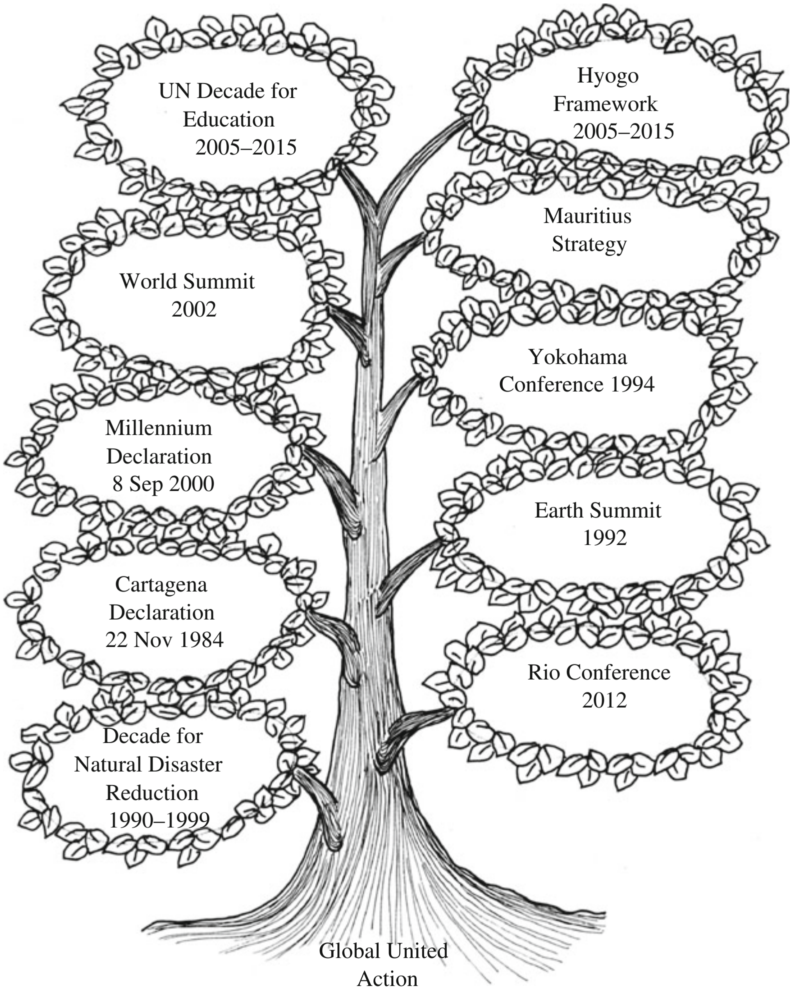


Fig. 5.14 The tree of the global initiative is growing but where are the roots and fruits?

International Decade of Natural Disaster Reduction (1990–2000)

UN General Assembly Resolution 44/236 of 1989 proclaimed the 1990s as the International Decade for Natural Disaster Reduction (IDNDR). A 12-point action plan was adopted by the Special High Level Council of IDNDR marking a big departure from the totally ineffective *Band-Aid* approach to Natural Disaster Management.

The Earth Summit (3–14 June 1992)

The Earth Summit (3–14 June 1992) was a game changer in that the need to establish culture of safety came to a sharper focus. It called upon all countries, in particular, those that are disaster prone to mitigate the negative impact of natural and man-made disasters on human settlements, national economies, and environment.

Yokohama Mid-Term Review of IDNDR (23–27 May 1994)

Upon review of progress of IDNDR evolved the Yokohama Strategy for Safer World. The main recommendations that emerged were (1) broaden the dialog related to disaster relief, environment, and development, and (2) institutionalize the growing culture of meaningful partnerships between national authorities, regional outfits, NGOs, private firms, etc., to ensure that prevention, preparedness, and mitigation become an acceptable part of development.

Cartagena Declaration (March 1994)

The Cartagena declaration of March 1994 directed disaster studies, which combine social with technical and scientific matters and civil society with government body in order to translate technocratic work into effective policies of disaster prevention and relief.

Millennium Declaration, September 2000

The Millennium declaration resolved to intensify global cooperation to protect the vulnerable, save the environment and reduce the number and effect of both natural and man-made disasters.

Interagency Framework for the International Strategy for Disaster Reduction 2000

UN General Assembly and the Economic and Social Council launched International Strategy for Disaster Reduction (ISDR). An interagency secretariat was created to serve as a focal point within the UN system.

World Summit on Sustainable Development 2002

The Summit was held in Johannesburg during 26 August–4 September 2002. The Johannesburg Plan on sustainable development, paragraph 37, advocates for an integrated multihazard all-inclusive approach to address vulnerability, risk assessment, and disaster management including prevention, mitigation, preparedness, response, and recovery for a safer world in the twenty-first century.

Bonn Conference on Early Warning 2003

The conference sought effective early warning systems through strengthening of coordination and cooperation among all relevant sectors and actors in the early warning chain.

Mauritius Strategy for Small Island States, January 2005

It gave a call for enhanced commitments to reduce the vulnerability of small island states, as they usually have inadequate response capacity.

Hyogo Framework for Action (2005–2015)

World Conference on Disaster Reduction held in Kobe, Hyogo, Japan during 18–22 January 2005 threw up a framework for action for the decade 2005–2015 popularly called the Hyogo Framework for Action. The priorities set for the decade include enhancement of international and regional cooperation, emphasis on an integrated multihazard approach to risk reduction, recognition of cultural diversity, empowerment of communities and local authorities, promotion of the culture of prevention, and recognition that every disaster is also an opportunity and disaster risk reduction is a cross-cutting issue.

United Nations Decade for Education for Sustainable Development (2005–2015)

The declaration made at this historic event aimed at disaster risk reduction through revision of school curricula at all levels and the use of other formal and informal channels to reach youth and children with information.

Besides above, we are richer with a number of related landmark conventions and UN Security Council resolutions. Some of these are listed below:

Landmark Conventions

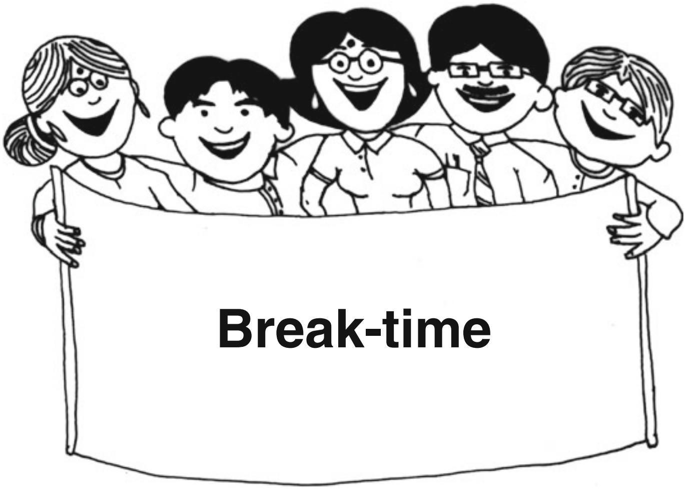
- International humanitarian law including Geneva Conventions of 12 August 1949: Protection of Civilian Persons in Time of War.
- The United Nations General Assembly in 2007 replaces the Interagency Task Force formed earlier with a biennial global platform on disaster risk reduction to support Hyogo Framework for Action.
- The Third Session of the Global Platform for Disaster Risk Reduction, held in May 2011, focused on mid-term review of the Hyogo Framework for Action through more than 130 country reports.
- Committee on Disaster Management of the Association of Southeast Asian Nations (ASEAN) developed a joint ASEAN–UN strategic plan for disaster management in March 2012.
- Economic and Social Council (ECOSOC): For strengthening of the coordination of the emergency humanitarian assistance of the United Nations. World Conference on Disaster Reduction adopted Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters.

United Nations General Assembly Resolutions

- General Assembly Resolution 42/169 and 44/236 of 1989:
  Declaration of the International Decade for Natural Disaster Reduction (1990–1999).
- General Assembly Resolution 46/182 of 19 December 1991:
  Enunciation of principles and framework for humanitarian action. The resolution asks the U.N. Secretary General to annually report on coordination of humanitarian assistance.
- General Assembly Resolutions 59/231, 58/214, 57/256, 56/195, and 54/219 of 1999:
  Economic and Social Council of the United Nations launched the International Strategy for Disaster Reduction (ISDR).
- General Assembly Resolution 58/114 of 17 December 2003: Gives to the world the great humanitarian principles of humanity, impartiality, neutrality, and independence.
- General Assembly Resolution 64/76:
  Rules and procedures for emergency response for the U.N. Secretariat for rapid humanitarian response.
- General Assembly Resolution 64/75:
  Introducing the idea of a trained, preidentified, standby national volunteer corps (White Helmets) placed at the disposal of U.N. Secretary General to support relief, rehabilitation, and reconstruction activities. White Helmets were certified as UN Disaster Assessment and Coordination (UNDAC team).

Food for Thought

- Our all out effort should be to reduce vulnerabilities. Hazards like earthquakes, volcanoes, and cyclones may be unavoidable but the disasters they cause are chiefly because of the human failures. Disasters occur only where people are vulnerable to hazards.
- Our effort should be to live in harmony with Nature. The so-called natural disasters are no longer natural. Natural events like earthquakes, floods, landslides, and cyclones are mere Nature's "safety valves" for relieving the "internal pain of mother Earth." What we really witness today is the fierce burst of Nature's anger at our hopelessly out of phase living styles, sky rocketing population and mindless urbanization, climate change, and the human interference with Nature, which is currently at its elemental worst.
- We have been left with no option other than to win the war against disasters. It can be fought only with strong political will, holistic perception, and the matching action on the ground. Our plan should, interalia, take cognizance of multihazard vulnerabilities and timeliness and speed of our response. The predisaster planning generally involves packages of short-, medium-, and long-term measures as a part of a holistic plan. It requires a robust and well-coordinated response system always on alert.
- Our aim should be to prevent disasters. Our priorities should naturally shift from post-disaster relief-centric management to disaster mitigation. Disaster mitigation is the term used to cover the whole range of activities and initiatives taken to reduce the impact of a disaster, in case it cannot be averted.
- Our highest levels of investments should go to disaster education. It is a silver bullet with which we can pierce deep into the whole range of issues connected with stopping of violence against nature, training of communities in the art of living in harmony with nature, mainstreaming of gender, and integration of disasters with development process.
- Safety is important but the culture of safety is even more important. Safety is what we look for but the culture of safety is what looks after us.
- Timely and reliable early warning and alert communities can avert disasters.
- Disaster knowledge networks and information communication systems are sufficiently advanced to provide real-time access to disaster-related announcements and information in the remotest parts of the world 24 × 7. Use them.
- Panic reactions, rumors, unscientific attitudes, and the huge gap between our speech and action invariably distance us from the culture of safety. Avoid these.
- Those who do not learn from disasters are condemned to suffer from disasters, over and over again. Disasters are outstanding learning opportunities. Every disaster offers an opportunity to build back better.



Break-time Question 15: Make an Internet search to find out what the historic global mega events, namely, United Nations Conference on Sustainable Development held in Rio de Janeiro, popularly called Rio +20 and Global platform on Disaster Reduction which opened in Geneva on 19 May 2013 concluded for us in the context of Disaster Risk Reduction.

Answer to Break-time Question-15

United Nations Conference on Sustainable Development (Rio + 20) held in Rio de Janeiro, Brazil during 20–22 June 2012 adopted the following resolutions in the context of Disaster risk reduction[3]:

186. We reaffirm our commitment to the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters and call for States, the United Nations system, the international financial institutions, subregional, regional and international organizations, and civil society to accelerate implementation of the Framework and the achievement of its goals. We call for disaster risk reduction and the building of resilience to disasters to be addressed with a renewed sense of urgency in the context of sustainable development and poverty eradication, and, as appropriate, to be integrated into policies, plans, programs, and budgets at all levels, and considered within relevant future frameworks. We invite governments at all levels as well as relevant subregional, regional, and international organizations to commit to adequate, timely, and predictable resources for disaster risk reduction in order to enhance the resilience of cities and communities to disasters, according to their own circumstances and capacities.

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[3] Extracted from Report of the United Nations Conference on Sustainable Development (reference: http://www.uncsd2012.org).

187. We recognize the importance of early warning systems as part of effective disaster risk reduction at all levels in order to reduce economic and social damages, including the loss of human life, and in this regard encourage states to integrate such systems into their national disaster risk reduction strategies and plans. We encourage donors and the international community to enhance international cooperation in support of disaster risk reduction in developing countries, as appropriate, through technical assistance, technology transfer as mutually agreed, capacity building, and training programs. We further recognize the importance of comprehensive hazard and risk assessments, and knowledge- and information sharing, including reliable geospatial information. We commit to undertake and strengthen in a timely manner risk assessment and disaster risk reduction instruments.

188. We stress the importance of stronger interlinkages among disaster risk reduction, recovery, and long-term development planning, and call for more coordinated and comprehensive strategies that integrate disaster risk reduction and climate change adaptation considerations into public and private investment, decision-making and the planning of humanitarian and development actions, in order to reduce risk, increase resilience, and provide a smoother transition between relief, recovery, and development. In this regard, we recognize the need to integrate a gender perspective into the design and implementation of all phases of disaster risk management.

189. We call for all relevant stakeholders, including governments, international, regional and subregional organizations, the private sector, and civil society, to take appropriate and effective measures, taking into account the three dimensions of sustainable development, including through strengthening coordination and cooperation to reduce exposure to risk for the protection of people, and infrastructure and other national assets, from the impact of disasters, in line with the Hyogo Framework for Action and any post-2015 framework for disaster risk reduction.

The Global Platform on Disaster Reduction concluded that accountability is critical for all actors. The main legislative and regulatory challenge of disaster risk reduction was to strike the right balance between improved resilience and available financial resources, allocating sufficient funds to vital areas without overspending.[4] The private sector was recognized as a key driver of innovation and investment effort.

[4] Session moderator Kevin Knight, Chairman, International Standard Organization (ISO) Technical Committee 262.

Prediction and Forecasting of Natural Disasters

6

Abstract

Differentiating between the terms prediction and forecasting, the chapter provides a brief on the current status of forecasting and early warning in the backdrop of success and failure stories. The speeds with which disasters strike, their prediction and people-centered early warning and indicators of crisis and emergency are discussed. The new generation of initiatives are introduced that provide ready access to global, regional, national, and local early warning systems and facilitate dissemination of early warnings.

Contents

Difference Between Prediction and Forecast

The terms *prediction* and *forecast* are *synonyms*, often used interchangeably. It is, however, important to understand the fine difference between the two, especially in the context of natural hazards. The word prediction is of Latin origin, a hybrid of words *prae* (meaning, before) and *dicere* (meaning, to say). Prediction, therefore, literally means *saying something beforehand*. The term *forecast* is also made of hybrid of words *fore* (meaning, front) and *cast* (meaning, to throw). The term *forecast* therefore means to *throw something upfront*. When we talk of prediction and forecasting in the context of natural hazards, for example earthquakes, basically the expectation would be that we clearly state the anticipated location of an earthquake, it is likely magnitude range and the window of its strike time to

R. K. Bhandari, *Disaster Education and Management*,
DOI: 10.1007/978-81-322-1566-0_6, © Springer India 2014

facilitate decision making. Merely declaring that an earthquake will occur next week is more of a scare than science and has no meaning.

One would then ask how does it matter if you *say something beforehand or throw the same information upfront*. The difference is that in prediction we make a binary statement (one single outcome)—whether earthquake will occur, or it will not occur. On the other hand, forecast will state a range of possible outcomes for the future in terms of probability of occurrence of an event, like probability of occurrence of an earthquake at a specific location within a certain specified magnitude range and in a particular window of strike time. Such forecasts are usually based on projection of the past into the future through in-depth study and analyses of the available data. The best example would be all too-familiar weather forecasts which are based on real-time analyses of available meteorological data. The speeds with which different types of disasters strike vary a great deal, Fig. 6.1. The consequences of short response (alert) time are usually fatal.

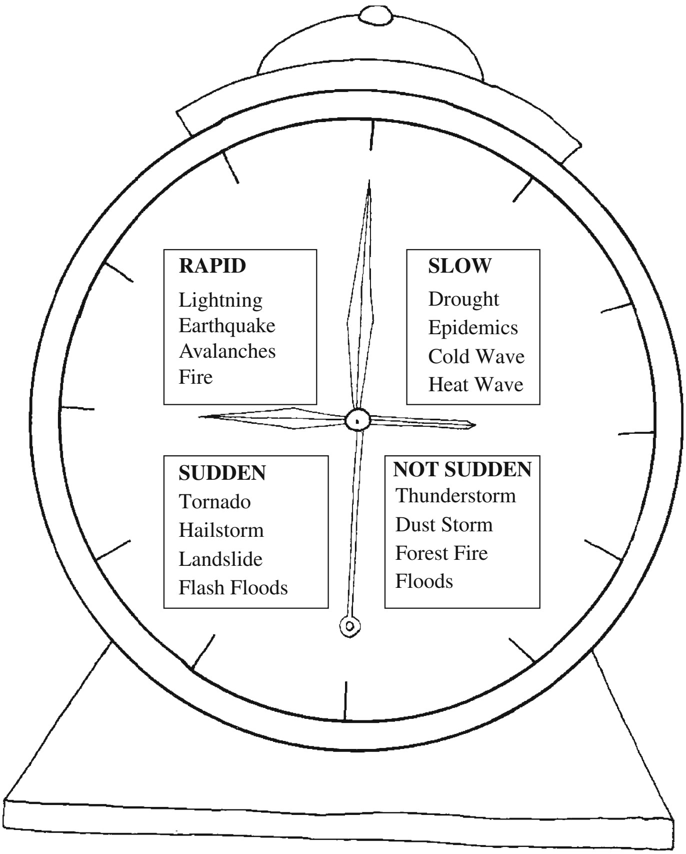


Fig. 6.1 Disasters can be slow, not so sudden, sudden, and rapid. Time and durations of their strike vary widely. For instance, effect of epidemics and drought last for months; floods and cyclones affect us for days; thunderstorms and tornadoes for hours; and earthquakes for minutes to seconds. Lightning does not even give sufficient notice to look at the clock

Forecasting and Early Warning: The Current Status

We are much closer to reliable forecasting of many types of natural hazards because of remarkable progress in weather forecasting, instrumentation, monitoring, and computational technologies. A few decades ago, weather forecasts were rather subjective and found to be invariably at variance with the actual weather, Fig. 6.2. Today, we rarely go wrong in weather forecasts. We are also quite at ease at making short- and long-term weather predictions which is why we are able to foresee natural hazards like drought, hurricanes, tornadoes, thunderstorms, and lightning well ahead of their occurrences. About 15 years ago, advance warning against tornadoes was given only for about 45 % of the cases. Today the figure is close to 90 %.

Prediction of natural hazards is much more difficult. Currently, we are able to predict many types of landslides with fair degree of reliability. In the case of earthquakes continuous tracking of crustal movements, seismic, geoelectric, geomagnetic, geochemical, geothermal observations and, geodetic and ground water measurements and reference to unusual animal behavior are regarded as

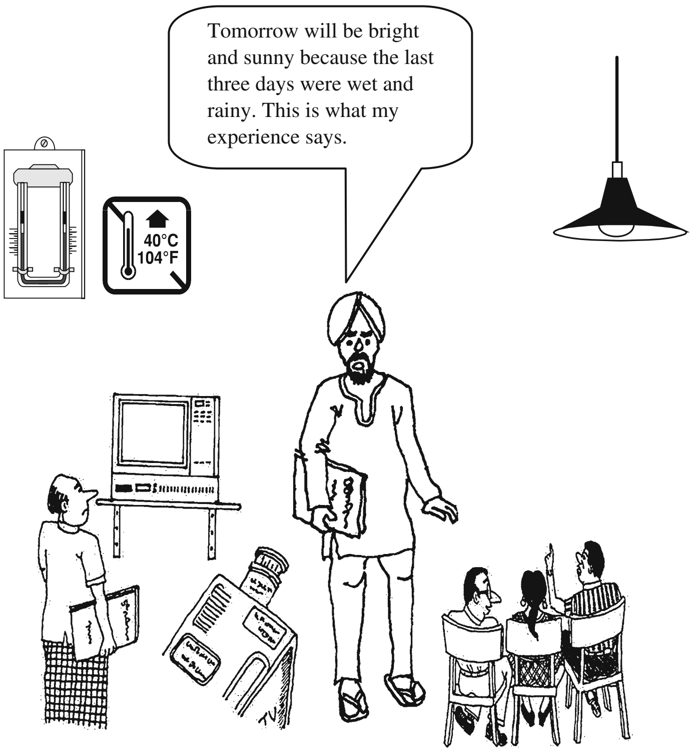


Fig. 6.2 The days of guess work are over. Meteorological forecasts have taken a quantum leap in reliability but the benefits are still to accrue across the digital divide

important indicators. Attention is also being paid to geophysical and geochemical methods, statistical analysis, chaos physics, ground and satellite mapping, atmospheric precursors and real-time monitoring to make predictions reliable. Despite all this, prediction of earthquakes and volcanoes remains beyond our capacity at the present time.

Success and Failure Stories

Success stories on prediction of drought, cyclones, floods, and landslides are numerous. Chinese reportedly claimed some success in the forecasting of earthquakes. In February 1975, they in fact evacuated 100,000 people from the city of Haicheng. And merely 2 h after the evacuation was complete that a major earthquake struck Haicheng. It killed only three people. This is by far the best earthquake prediction made so far. However, the same Chinese, a year later, failed to predict the Tangshan earthquake of July 2006 in the Northern China and we

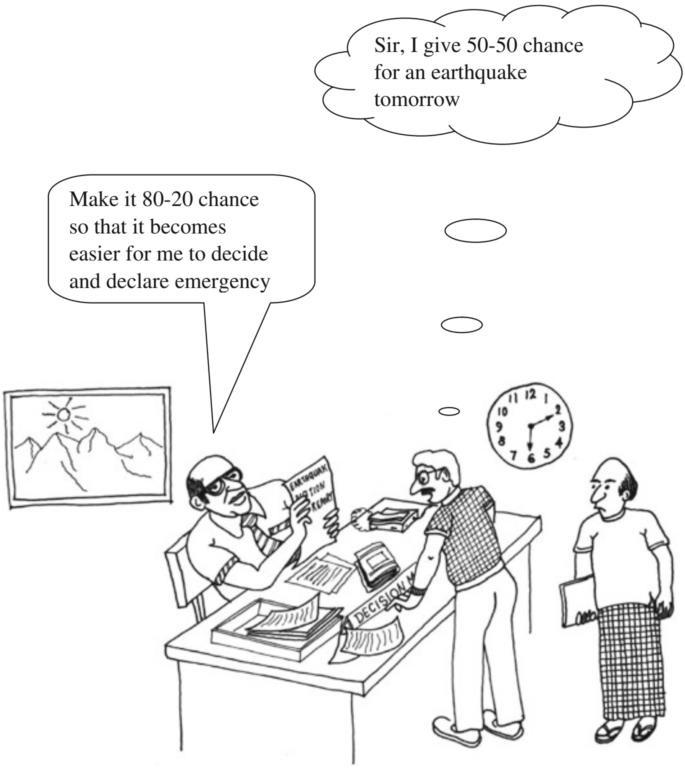


Fig. 6.3 Chance predictions like 50–50 are worse than no predictions. A scare is created, rumors spread, and the life in the town comes to a grinding halt

have not heard of a similar success story from the Chinese or any other since the Haicheng earthquake.

Although failures are much more important than successes in science, the reasons of failures decide whether a wrong forecast is because of a scientific error of judgment or because of a baseless assertion of little minds. Wrong prediction in itself is a disaster. Consider the false alarm of an earthquake sounded in late 1990 in central United States which made millions of people to suffer from inquietude, hundreds of thousands of student lost many days of attendance at schools, and over \$100 m had to be spent on earthquake insurance. These figures only speak of the negative social and economic impact of this false prediction. The consequences could be much worse if restraint is not exercised on unscientific predictions, Figs. 6.3, 6.4, 6.5, and 6.6.

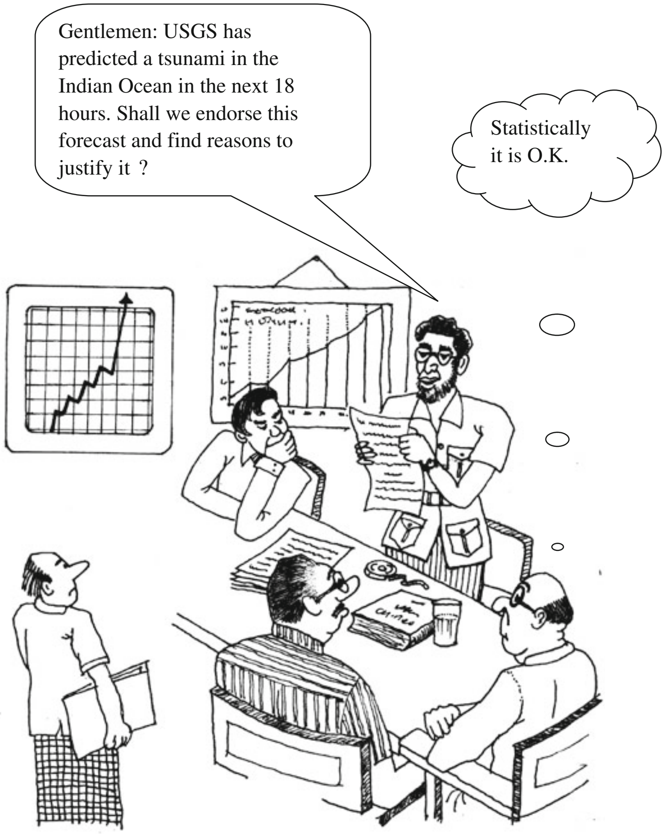


Fig. 6.4 An unsophisticated forecaster uses statistics as a drunken man uses lamp-post for support rather than for illumination

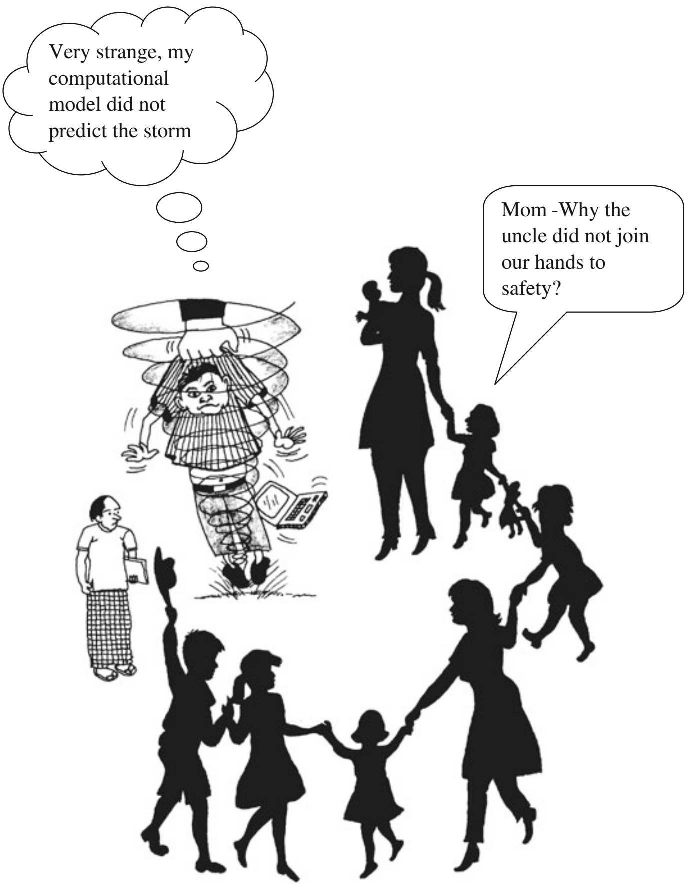


Fig. 6.5 Storm predictions theories are far from perfect. The only theory that works in the crisis times is the theory of common sense

In late 1893, Acharya Rajneesh reportedly warned his Californian followers to leave the State by the year's end.[1] He predicted a 15-year-long series of natural and man-made catastrophes, including earthquakes, volcanic eruptions, violent storms, and nuclear holocaust. According to him San Francisco, Los Angeles, New York, Bombay, and Tokyo were among the most vulnerable. The year of prediction 1984 and the 15-year period climaxing in 1999 is already behind us to show that bogus predictions of this kind without any scientific basis can do more harm than good.

There is often an unjustified criticism of the national governments that they failed to predict a disaster and forewarn the public in time. Consider a forecast with 50–60 % probability of a major earthquake at some location in Assam. If

[1] Forecasts—Clairvoyants.

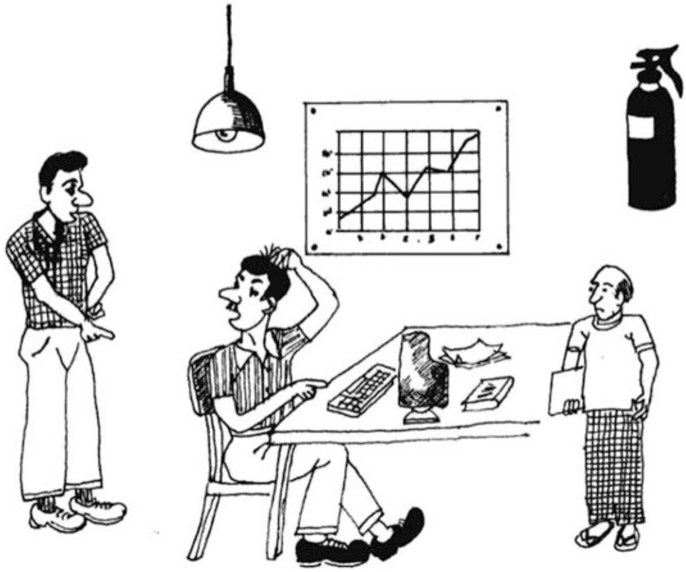


Fig. 6.6 You see my prediction was right; somehow I got the place wrong

such an earthquake were indeed to occur, thousands would perish and millions will be rendered homeless. How should then the government handle such a forecast? If they neglect it because of the low probability of occurrence, and the earthquake indeed arrives, government will almost certainly be blamed for inaction. If the government acts fast and spends public funds on preventives, it would be blamed for wasteful expenditure in the face of many important projects held up for want of funds. Every failed forecast will be blamed for creating fear psychosis, panic public reaction, and media gossip. It may divert attention from real issues and cause disruption of normal life, speculations on land prices, rise in insurance premium, mass exodus, and mob violence. Public awareness is the only way to ensure that it understands the uncertainties and learn to believe in the value judgment of the government.

Prediction- and People-Centered Early Warning

Early warning saves lives, provided the warning is early enough for communities to respond. Success usually depends on reliability and timeliness of the alert, swiftness with which those affected are informed, risk perception, degree of faith in the alert, and quick response. Some of the indicators of emergency are shown in Fig. 6.7.

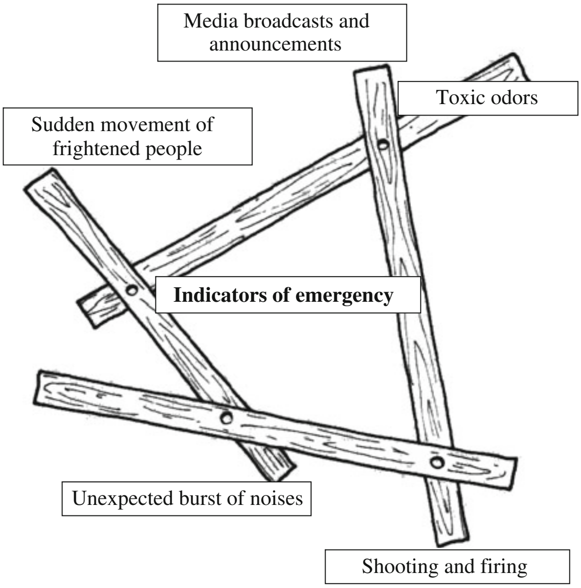


Fig. 6.7 Crises and emergencies have a thousand ways of showing up. We need to carefully assess the dynamics of prevailing ground situation and then respond to emergencies accordingly

Wrong prediction of a disaster and inappropriate early warning are a big worry but an unheeded right prediction is an unforgivable crime. Reliable and sturdy instrumentation, real-time monitoring and data processing can help us predict hazardous events but lives can be saved only through swift, matured, and measured community response. There are examples where prepared and alert people with commonsense approach succeeded at a time when official warnings had failed. Consider for example the massive earthquake off the coast of Sumatra that triggered the Tsunami of December 2004.[2] Seismological instruments were successful in recording the earthquake but there was no way to warn people of the catastrophe in the making. It resulted in loss of over 2,85,000 lives.[3] Is it, therefore, not an eye opener that in the same tsunami attack, 3,630 lives were saved in Nallavadu, on the eastern coast of India by a person to person alert based on radio news conveyed through a telephone call from Singapore in the early hours of 26 December 2004[4]?

If the people are not fully educated, they will interpret the same forecast differently. If not made fully aware of the fatal consequences, they are likely to take warnings light. Disaster education is the only way to eliminate such possibilities.

[2] Great Tsunami. Publication of the Geological Society of India, Bangalore, 2005 and Geometrics in Tsunami, a publication of the Department of Science and Technology, New Delhi and Centre for Remote Sensing, Bharathidasan University, Tiruchirappali.

[3] Tiding over Tsunami, A Report of the Government of Tamil Nadu, December 2005.

[4] According to World Disasters Report 2005 published by International Federation of Red Cross and Red Crescent Societies, the phone call was made by Vijay Kumar Gunasegaram from Singapore to his family in Nallavadu. His family in turn alerted the villagers.

Community-centric early warning systems should be effectively backed by flow of authoritative inputs in real time.

Effective use of media can make a huge difference in the public perception of a disaster early warning. Great benefits accrue when media takes recourse to responsible reporting after checking facts. Rushing to broadcast without verification of the information and validation of data can cause substantial damage and embarrassment.

One of the major concerns that need to be repeatedly flagged and vigorously addressed is the lukewarm public response to safety guidelines. Even if the prediction is reliable and public response is swift, lives will be lost because of some other reasons. Large populations continue to live in unsafe houses under the shadow of disasters and lack awareness, appreciation, and resource to remedy the situation. Worse still, noncompliance of design codes, spurt of unchecked non-engineered, and poorly built new constructions add considerably to our woe and worry.

Let us consider the example of the huge cyclone which hit the coastal areas of Bangladesh on 20th and 30th April 1991. The Bangladesh Meteorology Department made the forecast and issued warnings in the threatened areas. However, the warnings were not taken seriously and the evacuation began only upon arrival of the cyclone. Why did so many people neglect the warning? One of the main reasons for doing so was the frustrating experience with the previous false alarm.

Public must, however, be made aware of the huge uncertainties and knowledge gaps in prediction of natural hazards and that there is no crystal ball to gauze them despite multiple indicators. Even if one were to predict a hazardous occurrence with reasonable degree of reliability, prediction of time of occurrence may be in error.

We need to create public appreciation of the severe limitations and uncertainties in forecasting and early warning of disasters and the varying speeds which they can strike. Public must also be made familiar with indicators of emergency. When Bhopal Gas Tragedy struck in India, the local government had no clue whatsoever on how to save lives whereas merely covering the nose and mouth with a wet cloth would have prevented deaths.

The above instances underscore the importance of continued research to enhance the scientific content of prediction methodologies and reliability of forecasts. No Government or institution can ever act on a prediction which fails to make a mention of time, place, and magnitude of the event on the basis of a sound scientific reasoning. And without scientific reasoning, we will only be supporting sensation over science. People need to be educated to understand the possibilities of false predictions also because of the uncertainties in knowledge.

Global Initiatives

Global initiatives aim to "provide ready access to global, regional, national and local warning systems, and dissemination of warnings".[5] What has been achieved in this direction is commendable; what further can be achieved is beyond imagination. Advanced geostationary and polar orbit satellites, Doppler radars and wind profiling systems, automated surface observing systems, and the interactive information systems have opened up new vistas and mind-boggling possibilities of great potential. Satellites have already been providing reliable, multispectral, multidata, synoptic information and data used for mapping, monitoring, forecasting, surveying of vulnerable and disaster-inflicted areas, and of damaged scenarios. The IDNDR infused a new life into a number of local, national, regional, and global networks. For example, many satellite-based networks consisting of digital seismicity and strong motion instruments, located in earthquake-prone areas, are fully networked and operational today.

Hazard-specific warning systems (tornadoes, hurricanes, floods, earthquakes, volcanoes, tsunamis, wildfires, and droughts) have all been perfected to a significant degree but many more new possibilities have opened up because of next generation of weather satellites. Such satellites do provide forecasters more frequent high quality images and new types of atmospheric soundings leading to advanced information about hurricanes, flashfloods, and other severe weather storms. A combination of seismic monitoring and tide monitoring, or a continuous monitoring of cyclones and floods, and use of this information to alert communities, saving lives, and property, are other examples. The World Meteorological Organization Technical Committee on warning systems report (1994) and the US National report 1994 are two of the dozens of outstanding publications which provide a glimpse of the breakthroughs in recent past. (distant future is best predicted by science fiction writers!)

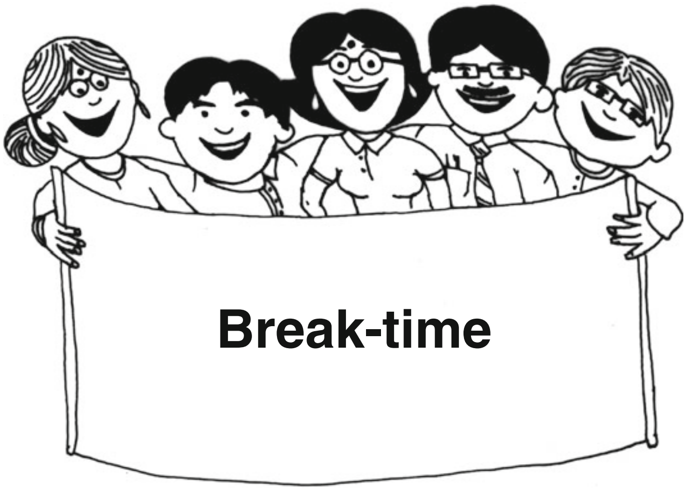
The effort to put in place a Global Emergency Observation and Warning Systems, (GEOWARN),[6] is both significant and laudable. GEOWARN utilizes satellite communications and global high-resolution remote sensing to provide disaster warning and relief support. According to Edin, GEOWARN is primarily designed to combat the effects of floods, hurricanes, earthquakes, droughts, etc., globally. The spinoff benefits include early warning against avalanches, deforestations, dust-storms, landslides, oil fires, tornadoes, tsunamis, volcanic eruptions, wildfires, and scientific applications. An added feature of GEOWARN is the linkage with the global disaster communications networks in order to access the existing sources of remote sensing data and ensure that crucial information reaches

[5] International Decade for Natural Disaster Reduction set the year 2000 to achieve this goal.

[6] (Edin, 1994).

its destination in good time. It is also expected that regional centers interconnected with the satellite links and data networks would provide services to the designated parts of the world.

Warning Systems are poised to move into much higher orbits of reliability with strengthening of the associated measuring systems such as Satellite Radar Imaging (SAR) and the Global Positioning System (GPS). One might also exploit air-borne system of SAR, Synthetic Aperture Radar, for relief support and damage assessment.



Break-time Question 16: What are your expectations of early warning alerts against disasters?

Answer to Break-time Question 16

1. The foremost expectation is that the warning alert should be timely because most disasters are quick to strike and they give very little time to respond. The authorities responsible for issuing early warning alerts must be sure of the (a) reliability of the hazard detection systems, (b) clarity of inflowing alert messages from the automated as well as human-controlled systems, (c) basic information on previously established area-specific hazard levels, (d) early warning criteria, and (e) robustness of alert dissemination apparatus at their disposal.
2. We expect the early warning systems for specific types of hazards like cyclones, earthquakes, and floods to be closely coupled with well-coordinated disaster response apparatus geared to respond to any combination of natural, man-made, or multiple emergencies.
3. Since individual safety is closely linked with the safety of others, we cannot be safe unless the national governments educate the people at large to take full advantage of the usually short early warning time and take on their own a wide variety of safety-boosting actions. Automated, preprogrammed response actions such as (a) transmission of most essential mass-text messages, (b) quick retrieval of their go bags containing helmet, valuables, medicines, radio, torch, and mobile charger, (c) soliciting help of mutual support groups to leverage capacities, and (d) access to developing guidance on the quick escape routes (not necessarily the shortest route) make a huge difference both to the individual and to the collective safety.
4. We expect early warning alerts backed by effective, coordinated, and synergistic action between the various players for quick decision making. Systems which are quick, dependable (sturdy and reliable), and capable of managing simultaneous wireless communications have helped in saving lives.
5. Early warning must necessarily be issued in the language victims can understand. Issuance of raw scientific information, frequent revisions of alerts, wasting time also on people unaffected, and disconnect with print and visual media can make early warnings worse than no warnings.
6. A clear distinction should be made between an early warning and advisories. Criteria to decide levels of warning and levels of advisories should be critically reviewed with every new experience.

Lessons in Disaster Risk Reduction and Management

7

Abstract

The history of mankind is full of disasters of a bewildering variety, one bigger than the other. They give us opportunities to learn lessons and use those very lessons to do things differently and more effectively. The chapter presents a few of the simple but powerful lessons in disaster risk reduction and management. In a sense, disaster management is like mounting a tiger which is why a disaster manager, to be true to attended challenges, requires out-of-the-ordinary commitment to the job, nerves of steel, survival skills, and determination to succeed. A danger foreseen is a danger avoided, and in the ultimate analysis, disaster risk reduction is as good as the team work.

Contents

Lesson 1: A Danger Foreseen is the Danger Avoided

The best way to manage a disaster is to anticipate it and prevent it, Fig. 7.1. According to Richard Frank *Dangers foreseen are the sooner prevented*. Cultivate the culture of prevention as a way of life. However, *Building culture of prevention is not easy. While the cost of prevention had to be paid in the present, its benefits*

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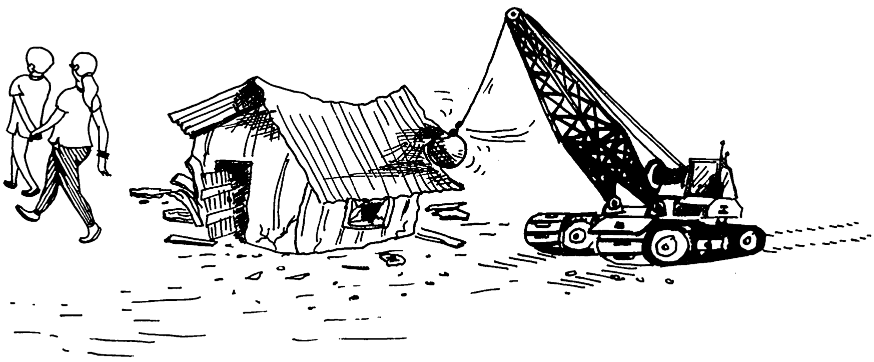

Fig. 7.1 A danger foreseen is the danger avoided

lie in the distant future. Moreover the benefits are not tangible; they are disasters that did not happen.[1] The famous Chinese proverb *dig your well before you are thirsty*, too means-act before a disaster strikes us.

Let us consider the story of a disaster defeated the Chinese earthquake of 4 February 1975 at Haicheng (Magnitude 7.3 on the Richter scale) was the first and the only earthquake successfully predicted and defeated so far. The warning of the imminent earthquake was issued at 10:30 h in the morning, followed with prompt evacuation, completed well before the earthquake struck at 7:36 h, the same evening. The Chinese were able to defeat the disaster because of this timely prediction, quick alert, and prompt evacuation. The string of frequent foreshocks and many other indicators were used for making the prediction, including the following[2]:

> Well water grew turbid and hibernating snakes took up their warm-weather rounds. Ground water levels rose and fell. Radon levels changed radically and sensors showed that the ground was tilting. Domestic animals behaved strangely. Pigs bit each other and tried to run up walls. Cows fought each other and pawed the ground. Deer ran away. Turtles were seen to jump out of the water and to make noise, and the hen was seen to fly to a tree top.

Now let us consider some stories of disasters amplified

Stories of Hurricane Katrina in the United States of America and Cyclone Bhola in Bangladesh are two striking examples of disasters in which the absence of preventive action and delayed response led to catastrophes.

Another notable example is of the Fukushima Daiichi nuclear reactor hydrogen explosion which could well have been prevented. The nuclear reactor at Fukushima got damaged because of the tsunami of 12 March 2011. The risk of a meltdown ranked extremely high on the global list of concerns. Catastrophe of an unknown dimension was imminent. Three other factors, namely, the questionable risk analyses, the discord between the prime minister's office and the chief nuclear

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[1] Kofi Annan, UN Secretary General 1999.

[2] Quoted by Charles Officer and Jake Page in their book on Tales of the Earth, p. 32, published by Oxford University Press.

regulator, and the confusion in decision-making process added *fuel to the fire*. This case-record is also being cited as an example of what non-compliance of decisions may mean in disaster management. In Fukushima, the order that injection of seawater into the reactor must be stopped was defied. Fortunately in this case, the defiance prevented a more serious melt down thereby containing the public outrage. In principle, such defiance must be punished as an act of indiscipline.

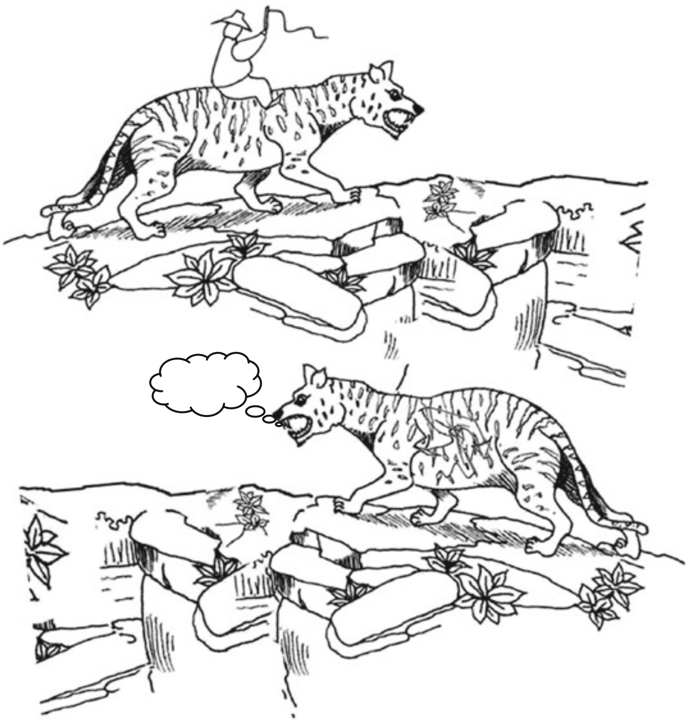
Lesson 2: Disaster Management is Like Mounting a Tiger

Successful disaster managers neither underestimate ferocity of a disaster nor overestimate their capacities to ride over. *Anybody can hold the helm when the sea is calm*.[3] The real test of a disaster manager is when sea is rough and hard hitting. Disaster management is as tough a task as mounting a tiger, Fig. 7.2 and the universe of disasters is not for the chicken-hearted novices or for the disinterested graduate jobseekers, Fig. 7.3. For one to become a disaster manager, true to its attendant challenges, one needs out-of-the-ordinary commitment to the job, years of hands-on experience, and a great desire to safe lives even if it were to be at the expense of one's own. We have heard of many such stories of valor and service.

We sometimes tend to overestimate the capacity of a disaster manager swayed by his or her bookish knowledge and the glare of academic track record. No matter how well-academically decorated one might be, without proper tuning of mind, honing of skills, and development of real insights, one runs the risk of getting stripped of those decorations without a moment's notice. The conventional disaster education packs the minds with all sorts of textbook theories, undigested case studies, untested standard operating procedures, and yet-to-be-validated knowledge products. Disasters in the real world are, however, no slaves of such an education.

What the disaster victims, communities, and people at large think of disaster managers in a horror situation make a huge difference to their morale and their ultimate fates. This is because, in the moments of crisis, communities, and people at large can be easily swayed from fear to courage, from hate to love, and from despair to hope by creating favorable winds of faith in the disaster management authorities. The faces of disaster managers as they appear to the people at large *make or mar* the public opinion. Glowing faces symbolize hope and the gloomy ones signal doom.

[3] Pubilius Syrus.



There was a young lady of Riga,
Who went for a ride on a tiger;
They returned from the ride,
With the lady inside,
And a smile on the face of the tiger.

Fig. 7.2 Managing Disasters is not simpler than mounting a tiger. Quotation: R.L.Green -In a century of Humorous Verses

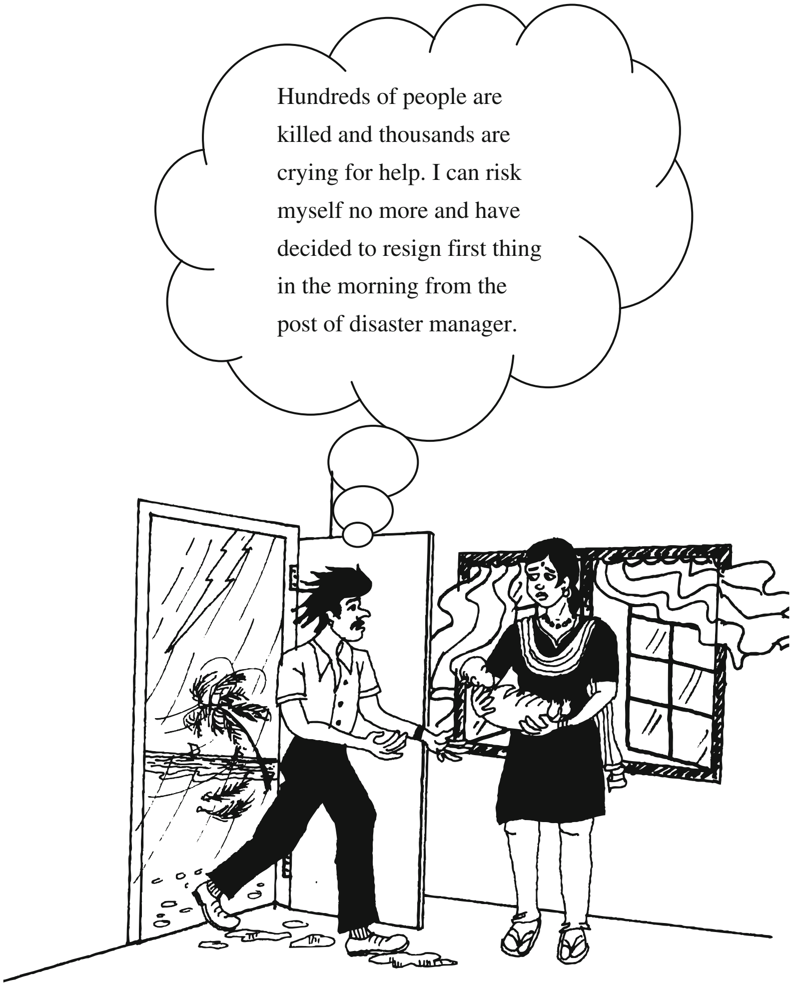


Fig. 7.3 A disaster manager is expected to rise beyond the call of duty. Imagine if a captain was to desert his ship in a rough sea!

Whenever a disaster gets underrated initially, the emergency response usually falls short of what is needed on the ground. Such a misjudgment may have several adverse implications. It may result in greater loss of lives, trigger secondary disasters, and add to the trauma and plight of the victims. Disasters, inadequately managed, may even turn bigger than they are at the start.

Disaster management capacity should not be overestimated especially because disasters often throw the government machinery haywire. In a post-disaster scenario with hundreds killed and thousands rendered homeless, if disaster managers are also killed or injured, the capacity to manage disasters will be severely affected, Figs. 7.4, 7.5, and 7.6.

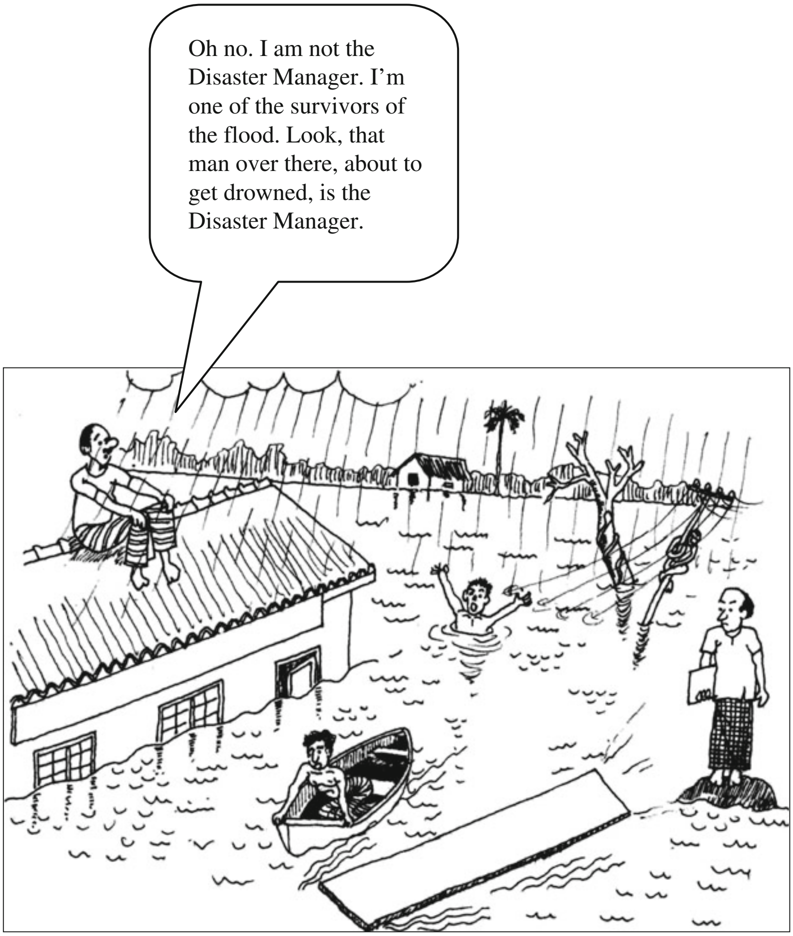


Fig. 7.4 Capacity Building and community preparedness are essential to face such situations effectively. "Disaster management is like steering a ship. Everyone in the community ought to be prepared to take the helm". *Source of quotation* unknown

Fig. 7.5 The universe of disaster management is not for the chicken-hearted novices or for the frustrated graduate job seekers. For one to be a disaster manager, true to the attendant challenges, he requires out-of-the-ordinary commitment to the job, related survival skills and experience, and a great desire to serve and succeed

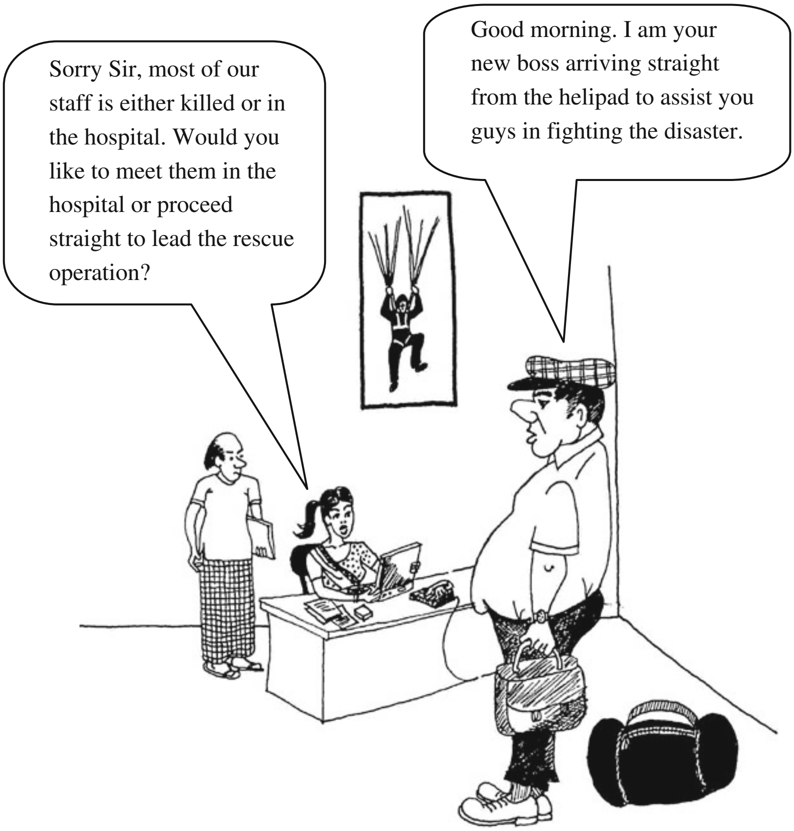


Fig. 7.6 Disaster managers should know that if anything can go wrong, it would do so in the worst possible manner

All the various phases of disaster management such as response, recovery, mitigation, or preparedness require adequate level of useable capacity including specialized training with modern tools and techniques. The main lesson is that one should neither underestimate the damage potential of a disaster nor overrate the disaster management capacity. The task of capacity building is never over. It is to be regarded as a work in progress.

Lesson 3: A Golden Rule in Disaster Management is that there is no Golden Rule

Successful disaster managers were never the slaves of premeditated plans and of the standard operating procedures but responded swiftly and adequately to the holistic and dynamic assessment of the rapidly evolving ground situations in a given case,

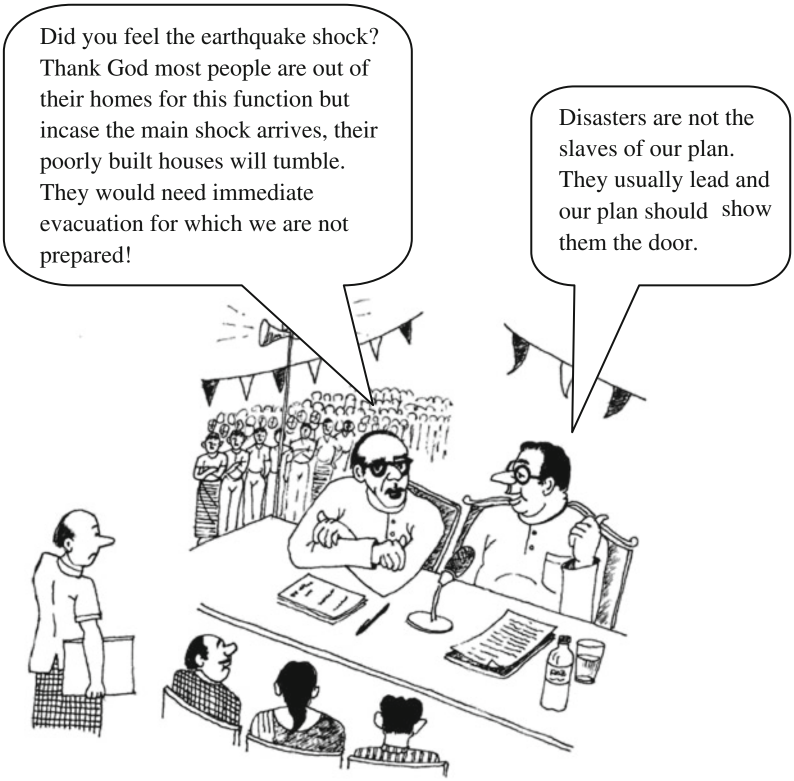


Fig. 7.7 In case the earthquake really strikes, use the fleet of vehicles we have brought here to evacuate the sick, the handicapped, women, and children to the nearest safe heaven. Requisition more vehicles, medical-aid, food, and water from the neighboring district. Motivate the village youth to facilitate evacuation. Resident doctors should be asked to be ready for first-aid and trauma counseling. I will revert to you after further consultations

in real time. In the real world, disasters lead and the disaster management plans follow, Fig. 7.7. Disaster management plans by themselves do not mean much if they are faulty in design or toothless. Success of disaster management effort generally depends on the effectiveness with which the disaster management plans get tuned to meet the demands of rapidly unfolding disaster scenarios and implemented maturely without creating avoidable problems, Fig. 7.8. Even with the best of preparedness, it is not always possible to effectively manage disasters because of the uncertainties and surprises, Fig. 7.9. In such cases, we need to think quickly beyond our premeditated disaster management plans and strategies. If anything can go wrong, it will go wrong in the worst possible manner, is one of the well-known

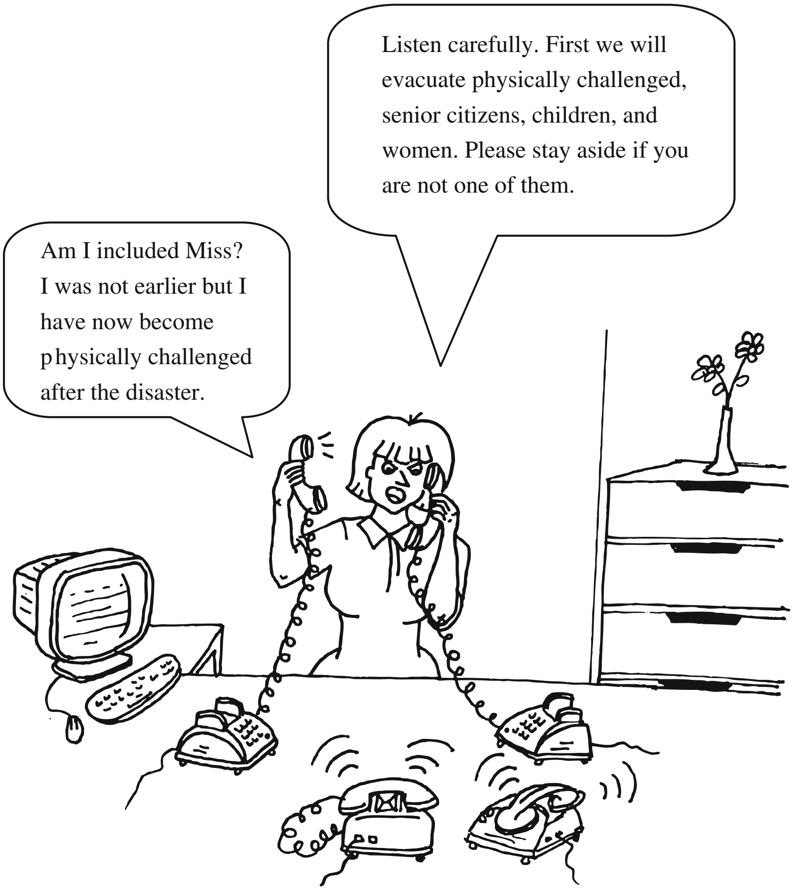


Fig. 7.8 Disaster managers need to be sensitive to the ground realities. They should simplify procedures and take decisions which can be implemented on the ground without loss of time

Murphy's Law. In the context of disasters, it would be wiser to assume that if anything can go wrong, most likely it has already gone wrong in the worst possible manner and it is time to act decisively and appropriately.

Crises often alter the very landscape in which the humanitarian actors are required to perform. When one crisis runs into another, a bigger crisis is born. In turn, it pressures and vitiates the working environment besides straining the decision-making process. The challenge lies in evolving systemic flexibility to be able to continuously renew response plans and take decisions as the ground situations demand, without losing the big picture, the overall sense of purpose, and direction.

Fig. 7.9 Very sorry folks that we have evacuated you to this wrong place. Let us at once get out of here and run for our lives because earthquake foreshocks are picking up to dangerous levels and the building we are in is an earthquake unsafe cyclone shelter

Lesson 4: Disaster Risk Reduction Initiative is Only as Good as the Teamwork

Successful teams are those who multiply hands (by forging partnerships between various players including local government, voluntary agencies, law enforcing agencies, paramedics, etc.) before they begin to use their own. Unutilized capacities and resources are a costly waste.

Disaster management demands both horizontal and vertical integration of interrelated institutions, capacities and resources to be able to achieve synergy of strengths, leveraging of capacities, pooling of resources, and overcoming of weaknesses, Fig. 7.10. It is the collective responsibility of all stakeholders and it requires holistic vision and coordinated team work. Very often, multiple agencies

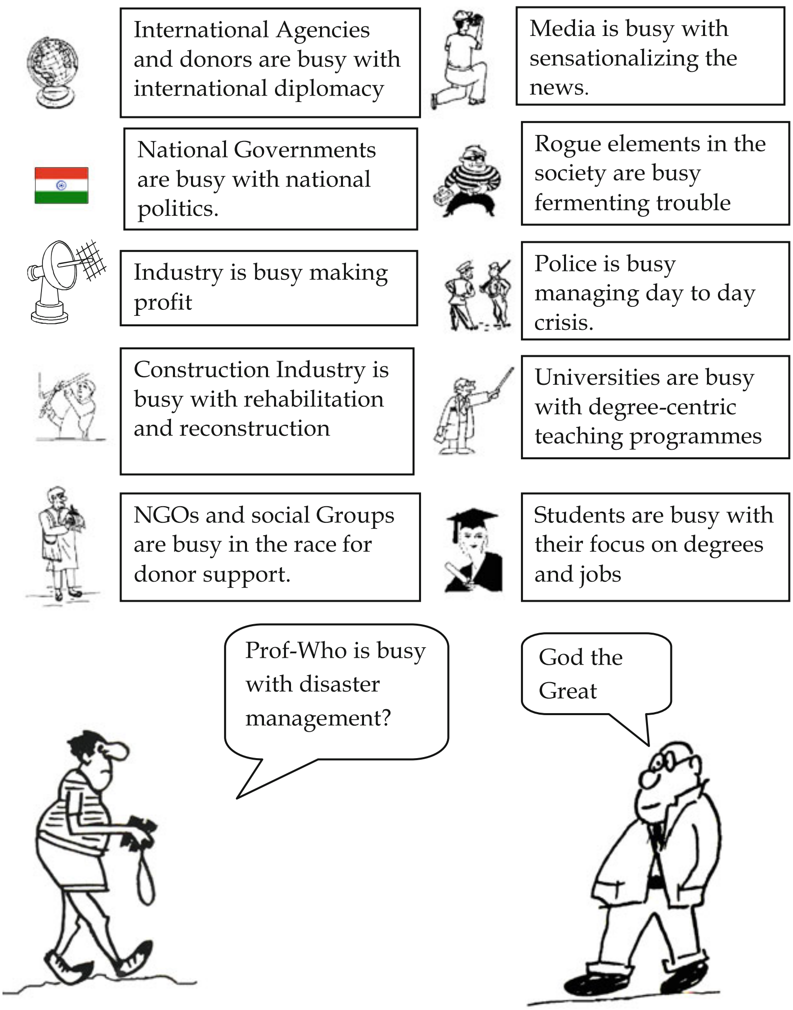


Fig. 7.10 There was a time when disaster management fell in the no-man's-land. Today, disaster management is the collective responsibility of all the stakeholders and it requires holistic vision and coordinated action from one and all

involved in the task of disaster management are seen to go their separate ways at their own pace, denying people the benefits of team work. Well-coordinated and cohesive teams with well-defined roles and responsibilities and an effective multiway communication between all parties are therefore critically important.

Emergencies of different magnitudes and scales invariably call for synergistic response at different levels. A synergistic response is possible only through vibrant partnerships between various humanitarian actors. For major emergencies, for example, national governments look for strategic partnerships at global and regional levels, besides drawing upon those at the national level which include civil society, local government, aid agencies, private sector, and multilateral institutions. As emergencies grow in their complexity, the urge to broaden and deepen partnerships will also grow. The challenge will lie in forging need-driven partnerships rather than supply driven partnerships. Partnerships for their own sake may breed delays and defeat the very purpose for which partnerships become necessary.

Effective utilization of the available capacity and resource is critical to the success of disaster management. Capacities and resources by themselves do not mean much if they cannot be fully tapped in the hour of need. Imagine people starving for food in a famine and food grains rotting out in nearby go-downs. Imagine rapid action rescue teams waiting at an airport for helicopters when victims cry under heaps of debris. Imagine a mess-up of alerts in cyclone early warning leaving no time for people to reach cyclone shelters. Imagine ambulances without drivers or fuel!

Disaster management authorities usually make huge investments in developing data bases, knowledge networks, and vibrant communication systems. Imagine if the authorities fail to reap the benefits of such investments in the crisis times because of systemic and human failures.

Besides effective multiagency coordination in crisis times, two other things become extremely critical. First, continuous redrawing of the big picture as it develops and second, boosting of the public perception and confidence in the soundness of the disaster management apparatus. Public perception is greatly influenced by the trend of short-term recovery in the aftermath of a disaster. A successful plan is one which focuses on immediate challenges at hand without compromising on the end-objective of minimizing overall losses, and preventing escalation of the crisis.

Lesson 5: Community-Centric Disaster Management System is the Best Assurance for Disaster Risk Reduction

Communities being the first responders to a disaster, their training and empowerment are hugely important. External rescue teams take time to arrive at the site of a disaster, which is why the brunt of responsibility comes on the shoulders of local government and communities, Fig. 7.11. Crisis situations get created whenever vulnerability overshadows the preparation levels. Prepared communities can reduce the catastrophic impact of crisis situations. Timely action by trained, smart communities can save lives. It is, therefore, imperative that reduction of vulnerabilities, building of multilevel capacities, and devolution of operational freedom right up to the grass roots level in the empowered communities should constitute key elements of a sound disaster management strategy.

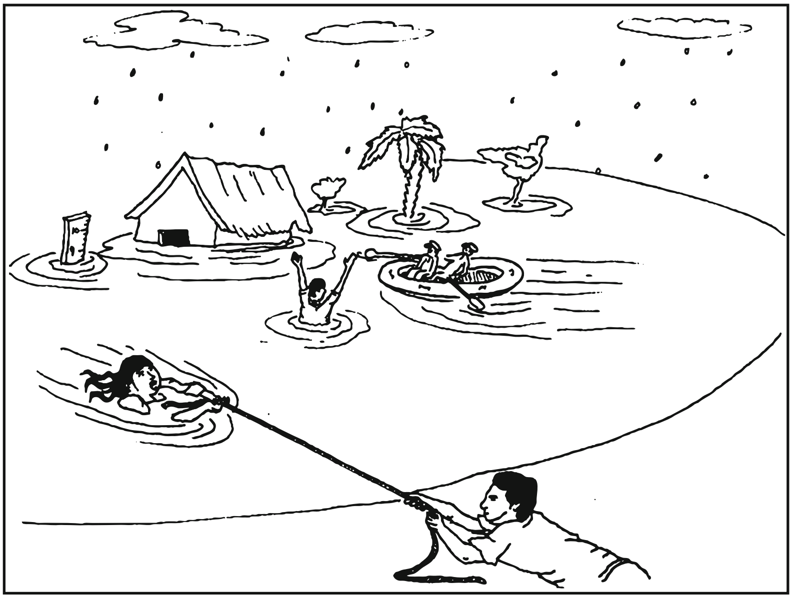


Fig. 7.11 Rescue teams usually take time to arrive at the site of a disaster, which is why communities are invariably the first to respond to crisis situations. Timely action using a commonsense approach can save lives. The above picture shows a post-flood scenario in a low-lying area frequented by floods. Every time a flood occurred, the community read the watermarks of the previous floods to assess danger. On one occasion, most people were evacuated and two-stranded people were also rescued by the first responders, as shown in the picture above

Lesson 6: Prioritize Between Vital, Essential, and Desirable

This is because in the crisis times, capacities, and resources are generally limited but there are no limits to the imagination with which scarce resources can be judiciously deployed and redeployed.

The post-disaster agenda involves a huge array of activities of differing priorities. A quick and decisive view on vital, essential, and desirable actions is essential to send the right message across the disaster management teams. The main thrust should be on saving lives by organizing timely evacuation, rescue, and relief. Special attention must simultaneously go to ensuring the functioning of electricity and water supply, hospitals, police stations, fire stations, public shelters, road and rail transport, and supply of food, medicine, and services.

Timely rescue and successful evacuations are possible when the public is well aware of the evacuation plans and when alert signals are timely, clear, and responsibly relayed and conscientiously followed.

It is vital to ensure that maximum attention goes to locations where the support systems have collapsed. For every plan, there should be a contingency plan, and resources should be redeployed where they are needed the most. Right kind of training in search and rescue and prompt delivery of medicare to the victims can save many lives, Figs. 7.12, 7.13, 7.14, and 7.15.

Fig. 7.12 It is never wise to endlessly wait for help. Victims themselves should make every effort to connect with the rescue team

Fig. 7.13 Body signals and body languages are the best ornaments seen from a distance in the hour of crisis. They should be made an important part of disaster education

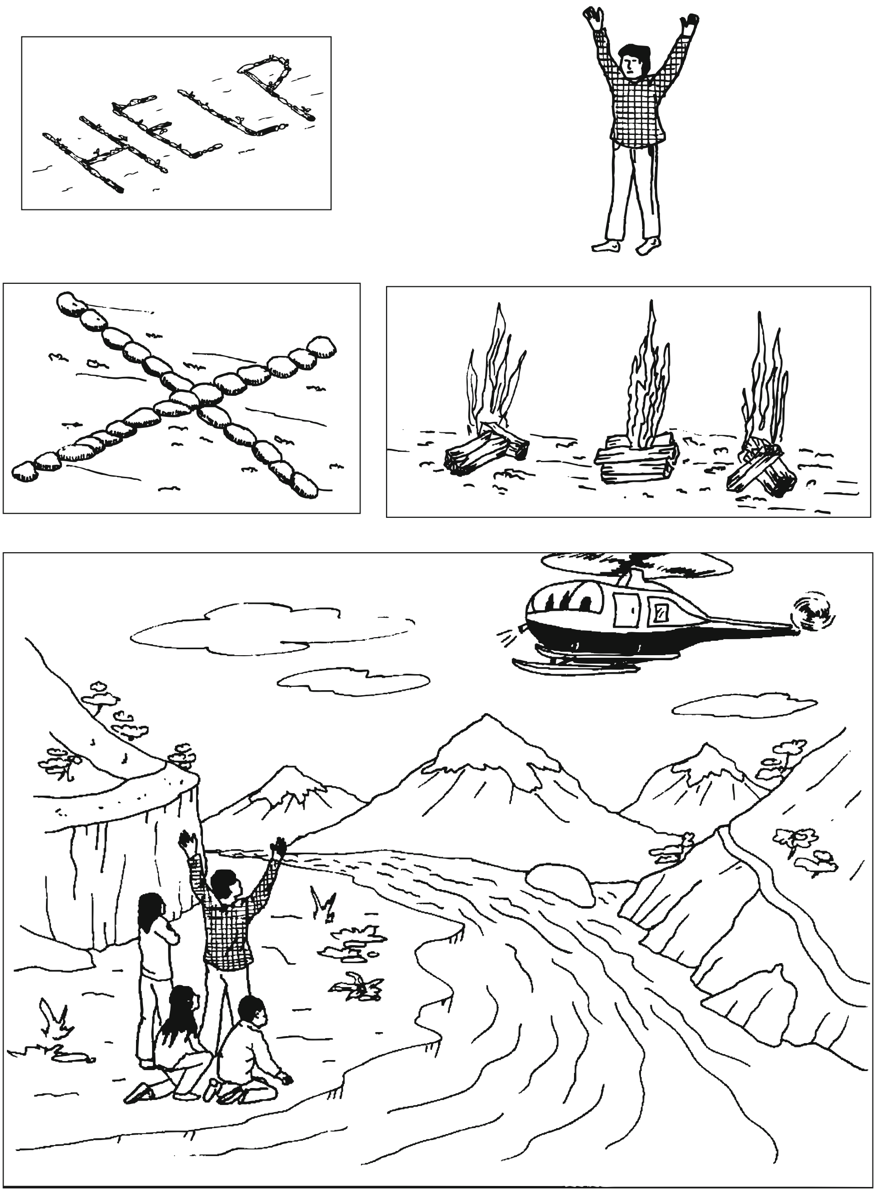


Fig. 7.14 It is important that we get trained in art of attracting attention of rescue teams by creating identifiable indicators on the ground and by our body language. We should be able to communicate with a rescue team at a distance without shouting our lungs

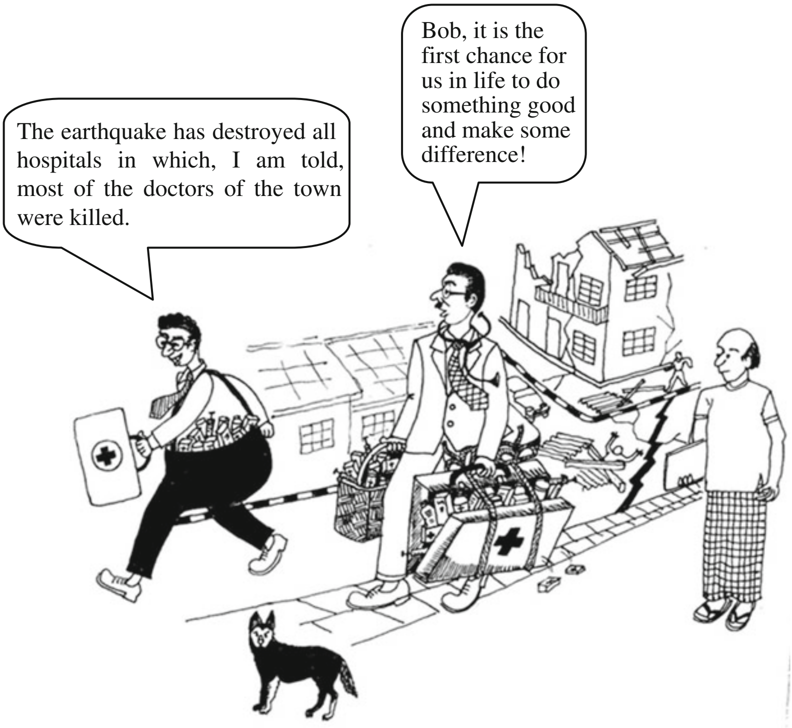


Fig. 7.15 More than doctors and medicines, victims need people who could understand their pain. We will discover that those whom we serve and who have felt through our labors the touch of the Master's hand somehow cannot explain the change which comes into their lives". *Quotation* President Thomas S. Monson

Lesson 7: Ensure Swift Flow of Information

Timely delivery of the right information to the right place at the right time effectively connects disaster managers with victims and the outside world. Pay utmost attention to information acquisition, filtering and reliability check, analysis, packaging and information dissemination with speed and accuracy.

Even the best of the information is of no use if it cannot timely reach the needy. Prompt opening of kiosks both in the physical and cyberspace, to serve as an interface between authorities, public, media, donors, and others is critical to the success of disaster response. Public too should be trained to rush vital information to the authorities simultaneously as the authorities make their own assessments and decode the body signals of the distant victims.

Fig. 7.16 Non-availability of right information at the right time is the worst thing that can happen to a relief and rescue team in the crisis time

Crisis response, especially in the present age of Information Communication Technology, is heavily influenced by the way we generate and disseminate huge flux of unstructured, multimedia disaster-related data, which may mean nothing without swift processing, cross-linking, checking, certification, and dissemination to the right people, at the right location, in the real time, Fig. 7.16.

In the preparatory, predisaster phase, easy access to information is necessary, inter alia, to educate people about government's vision, plan, and strategy to prevent and manage disasters. Public should be taught to ask right kind of questions and all their questions need to be promptly and satisfactorily answered. Disaster risk reduction programs need to be comprehensive and of practical value.

In the post-disaster phase, especially during the crisis times, there would be a huge pressure of demand to know more about every aspect of the unfolding disaster and its ghastly consequences. People would like to locate their near and dear ones amidst widespread chaos and their patience would run out fast, if useable information is not made available to them promptly. There was a time when flow of information was very slow and powerful remote sensing technologies were not available even to easily locate sites of disasters. People even relied on movement of vultures. Today we live in the age witnessing revolution in Information Communication Technologies and are in a position to ensure timely delivery of right information at the right place.

Wherever there was a carcass, the vulture used to gather, be that in a battle field or at the location of a post-disaster scenario. There was a time when rescue teams in wilderness took cue from the direction of movement of vultures in arriving at the scene of a disaster. Vultures are known to have the uncanny ability to detect decaying flesh and carcass even when buried, for instance, under an avalanche or under a post-earthquake mound of debris. This is because of their extraordinary sense of smell and very sharp eye-vision.

It is unfortunate that vulture population is on the verge of extinction which is why we see decaying dead-bodies in a post-disaster scenario and yet no vultures within sight. Animal lovers across the globe are fighting the last-ditch battle to revive the vulture population. If and when that happens, trained vultures can be part of our rescue teams.

Lesson 8: Disasters are Opportunities

Disasters offer open-ended opportunities to build back better by making good use of (a) the lessons learned from the past experience, (b) innovations in technology, and (c) projected future needs of people and development.

Disasters open doors for holistic recovery. Holistic recovery involves reconstruction, rehabilitation, and development of the affected area in tune with the felt needs and aspirations of the affected people ensuring future safety and sustainable development. Clearly the phrase *build back better* will have to be understood in the above context.

There is a need to sound a word of caution. The overzealousness in building back better should not be at the expense of timely delivery of essential support to the victims. Ambitious projects, devoid of political patronage and adequate resource are likely to get caught in the quicksand of bureaucratic delays defeating their basic purpose. Foresight and forward planning are essential for success of a rehabilitation programs without compromise on speed of action and timely delivery.

Disasters also create jobs at a time when the poor people affected by disasters are without basic income to make their two ends meet, Fig. 7.17. One of the ways to strengthen the poor at such a critical time would be to provide employment and pay them as per their competencies. Reconstruction schemes can also be so designed as to provide a component of self-help in order to give the poor dignity of living by their own labor rather than placing them on the doles. Whenever committees are constituted, their recommendations should be conscientiously implemented, Fig. 7.18.

The other factor on which success of rehabilitation programs critically depend is the effectiveness of the floor coordination. It is important to introduce transparency, ensure accountability, reduce wastages, engage communities, provide feedback to donors, proactively feed the news to the media, and shield such programs from the menace of corruption, Fig. 7.19.

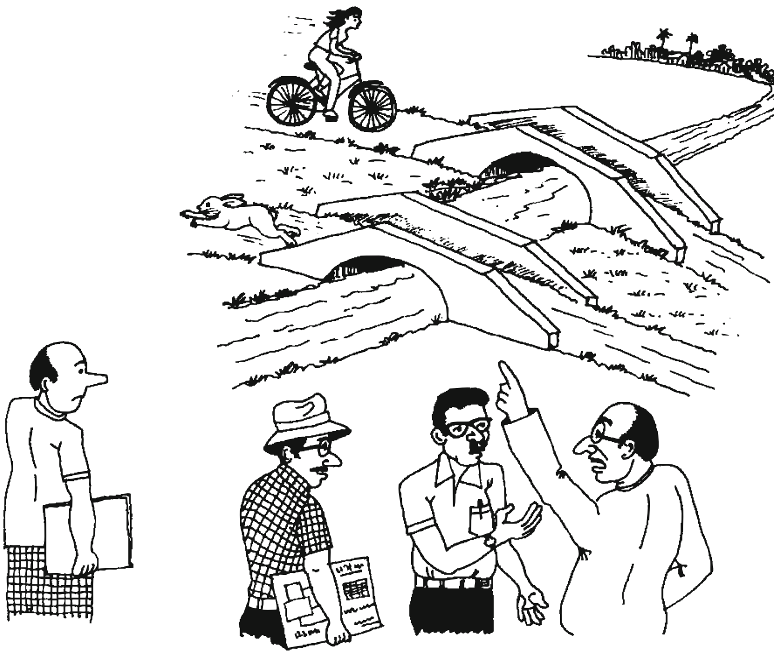


Fig. 7.17 Do not complain. Know this that we could create so many more jobs by building two bridges. When one of them gets destroyed because of the next disaster in the next couple of years, the other will serve as a standby. This is a part of our forward planning, you see!

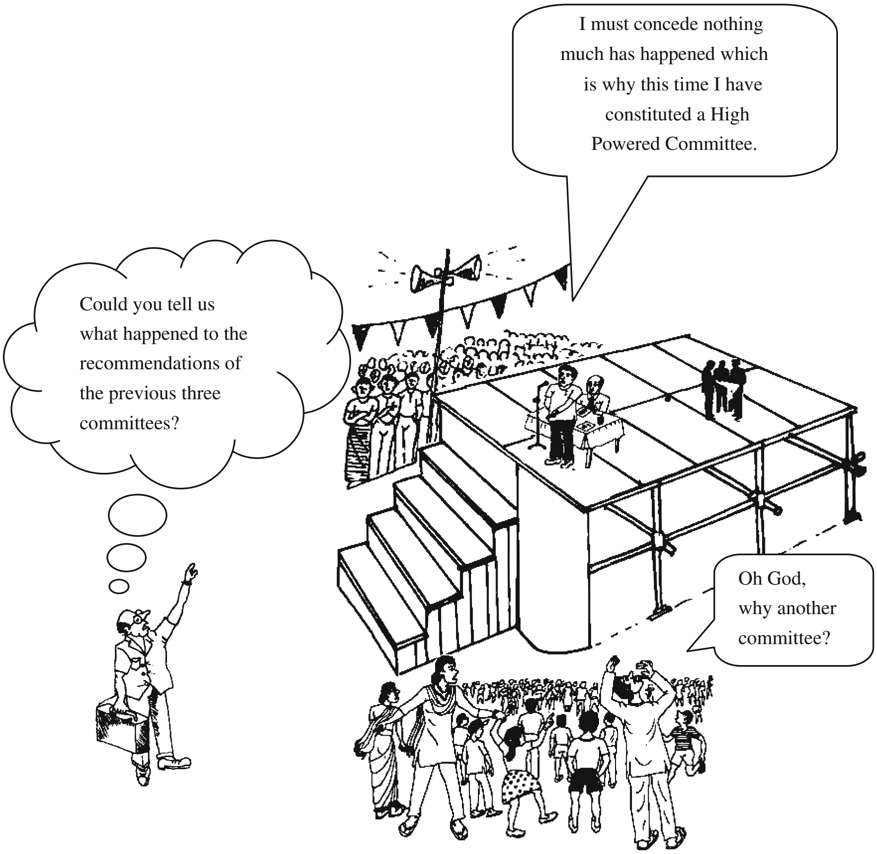


Fig. 7.18 The practice of constituting a committee to investigate and report after every disaster must be matched with conscientious implementation of the committee's recommendations and monitoring of the outcome and impact

Fig. 7.19 Corruption-free delivery of relief to the victims is a matter of critical importance in Disaster Management. Cartoon published in Hindustan: 15 September 2008, soon after the devastating Kosi floods in India

Lesson 9: Disasters Often Come in a Row

A disaster often becomes a bigger disaster when problems begin to pileup. Additionally, worsening law and order situation, encourages lootings and tax the imagination of disaster managers to the point of its break down.

Nothing can be worse than breakdown of law and order in the times of crisis. Vulnerability of police stations, hospital buildings, fire stations, disaster control centers, and administrative offices of the government gives rise to public unrest and break down of the law and order situation. Post-disaster thefts and lootings are very common. These, to a significant extent, compound the pain of the victims. Such possibilities must be foreseen and disaster management squads should have specially trained people to take effective control of such situations, Figs. 7.20 and 7.21.

Fig. 7.20 Deceit and loot are not so uncommon in disaster times. Cool and alert minds can make a huge difference to personal safety and there is no substitute to it in the crisis times

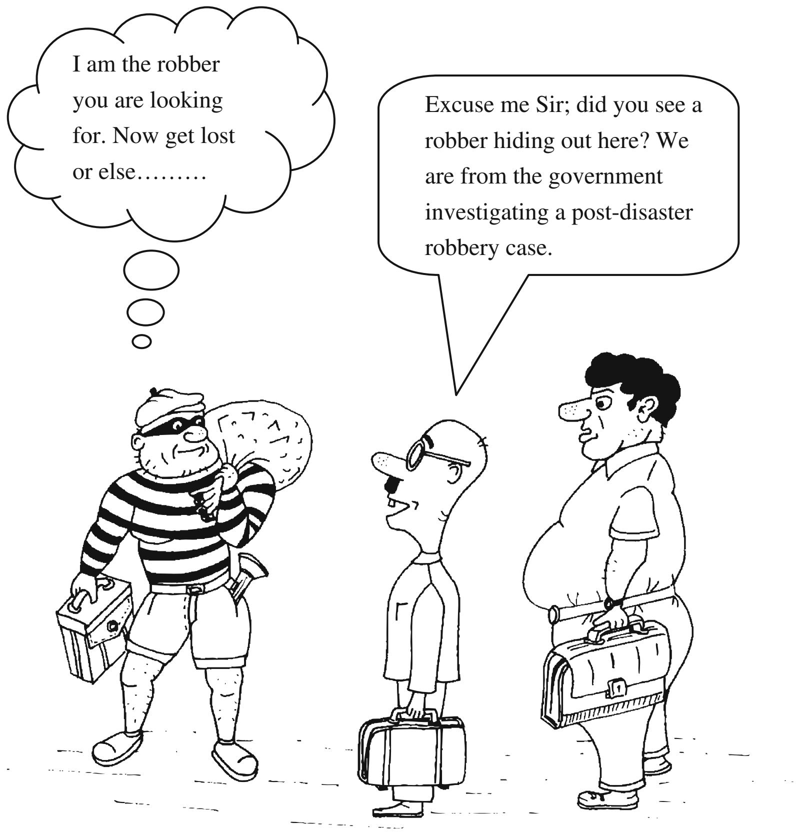


Fig. 7.21 Unless there is a fear of law enforcing institutions and highly trained squads to man them, post-disaster lootings and chaos cannot be contained

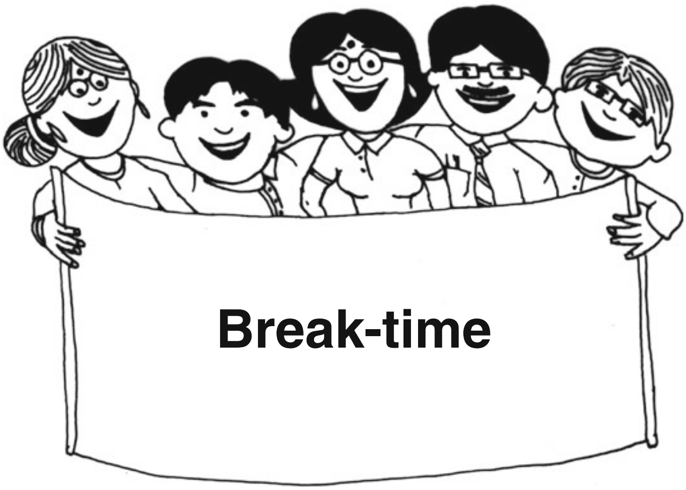
Lesson 10: Uphold the Core Principles of Emergency Response

Management of a humanitarian emergency chiefly involves meeting out the essential needs of the people affected by disasters, alleviating their human suffering, and restoring their right to live with dignity. For those displaced to the refugee status, it is now agreed by all that they shall not be forced to return to their native land or to a country in which they will be unwelcome or unsafe. In resource starved environment, humanitarian actors are usually guided by well-laid minimum standards in humanitarian assistance as applied to housing, food, water supply, sanitation, health, and nutrition. All parties including the national governments, non-State actors, and humanitarian organizations are expected to respect the core principles of humanity, impartiality, neutrality, and independence.

Consequences of crises and emergencies often lead to human sufferings of varying severities. Higher the vulnerability of those affected by disasters, greater is the human suffering. Vulnerability of those affected varies with the levels of their preparedness and the swiftness of the emergency response. Where people are caught unawares or unprepared, human suffering is certain. Disasters also create a caseload of homeless, besides hurting the process of development. People are sometimes forced to flee from their homes to some unknown destinations virtually *without any compass and support*. Such people are called *internally displaced people (IDPs)*. When forced to flee across the territorial boundary of their native country, they become *refugees*. Whether IDPs or refugees, people become traumatized, insecure, and critically dependent on the national governments, the international humanitarian community and the humanitarian aid workers.

Response to emergencies created by protracted crisis situations, such as due to prolonged conflict or civil war, spill over a much longer length of time. Here the challenge lies in recognizing the changing patterns of vulnerabilities due to climate change, urbanization, population explosion, water scarcity, food crisis, energy deficit, and economic meltdown. Mapping of vulnerabilities resulting from physical, environmental, economic, demographic, technological, political, and legal factors require particular attention.

Holistically speaking, response to disaster-induced emergencies must look way beyond alleviating the immediate human sufferings. Once the rescue and the relief distribution phases of the response are over, focus must squarely shift to rehabilitation, reconstruction, and development. Addressing the short-term humanitarian agenda as well as the long-term rehabilitation and development agenda in symbiosis, and well-coordinated interventions based on evidence-based decision making should top the composite agenda for action. Separate handling of humanitarian and development agendas should, therefore, be regarded as a race in parallel merely for the operational convenience, with eyes fully set on the end objectives.



Break-time Question 17: What is expected of the public in a post-disaster scenario? Give two examples. What does the public in turn expect from the government in the event of a disaster?

Answer to Break-time Question 17

(1) Never flock at the site of a disaster. Hampering of relief operations is a crime because it may cost disaster victims their lives, Fig. 7.22, (2) maintain exemplary patience and discipline and queue-up if you are the recipient of relief, Fig. 7.23.

Fig. 7.22 People gathered to watch the post-disaster scenario after a landslide in the southern part of India

Fig. 7.23 We need to show utmost restraint and discipline during relief distribution

The public expects swift response. The point can be best understood by imagining the following possible future earthquake scenario projected for Kawasaki, a Japanese City.[4]

"Kawasaki is an industrial coastal city in Japan with a population of about 1.2 million. It is located south–west of Tokyo across the Tamagawa River, with Yokohama city on the south–west side. The city covers a 30 km long stretch of land, 5 km wide, from south–east to north–west with its south-eastern edge forming a coastal area along the Tokyo bay. On a winter weekday evening at 5 p.m. an earthquake of magnitude of 7.9 strikes Sagami bay. The Urgent Earthquake Detection and Alarm System (UrEDAS) of the Railway Technical Research Institute (RTRI) detects the arrival of P-waves from its own observation network and instantly determines the magnitude and location of the earthquake. The automated system stops the bullet trains (Shinkansen) moving at 250 km or above on the Tokyo, Osaka line. Simultaneously, RTRI's Hazard Estimation and Restoration Aid System (HERAS) go into operation to collect damage estimations relating to the railway system. The HERAS system is capable of providing damage information on railways and associated facilities in just about 5 min of an event. This information is used in the recovery and restoration operations of the railway systems. At the same time, the Seismic Information Gathering and Network Alert system (SIGNAL) of Tokyo Gas company goes in operation shutting off gas supply automatically in areas where ground shaking exceeded a prescribed threshold, in order to prevent fires from secondary damage such as gas leaks.

On the government side, the damage assessment and support system of Kawasaki City, which became operational in 1994, is activated. The system gathers real time earthquake information form a dense observation network, calculates ground motion and estimates probable damage by combining the ground motion estimates with the information from a Geographic Information System

[4] *Source* IDNDR Report on Technology for Disaster Reduction undertaken under IDNDR Program Forum 1999.

(GIS) consisting of soil, land cover, infrastructure, population distribution, housing conditions and lifeline information. The estimated damage due to this earthquake will be on the order of 1.3 trillion yen, with about 91 % of the 33 thousand wooden buildings predicted to be destroyed by fire at the prevailing wind speed of 6 m/s from NNW direction. Fatalities will be up to 3120, road damages would be up to about 250 locations. There would also be widespread destruction to lifeline systems such as water supply and gas supply, which would require more than a month for complete recovery."

Guide to Safety

8

Abstract

The ultimate objective of all efforts is twofold: to ensure individual as well as collective safety against all types of disasters through pre-disaster strategic thinking, planning, preparedness, prevention, and to reduce risks and minimize losses through timely interventions and swift post-disaster response. The chapter serves as a "Dummies Guide" to safety against earthquakes, landslides, tsunamis, cyclones, thunderstorms and lightning, dust storms, floods and fire. It also provides simple tips for personal safety at school, home, and place of work.

Contents

R. K. Bhandari, *Disaster Education and Management*,
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Guide to Personal Safety

Tips for Personal Safety

- Always remember 4C's—calmness, commonsense, consensus, and communication.
- Learn to anticipate danger and remedy the problems before they occur. Draw your own safety plan and continuously improve it by experience. Disasters foreseen are disasters avoided and prevention is always better than cure. Familiarize yourself fully with the threats, hazards, and risks that you are likely to face in your day-to-day life Fig. 8.1.
- Always wear your ID card as a part of your dress. Your identity card should carry your name, full address, contact numbers, blood group, and contact of your immediate relative, your employer, and your personal doctor.
- Mobile phone is the first identity to your rescuer. Always keep your mobile phone charged and ensure that it receives all alerts, directions, and appeals relayed by disaster management authorities, empowered institutions, and media. Do not rely on chat messages from unverified sources.
- It may not always be possible for you to avoid accidents. You may need immediate attention, and even medicare, incase something happens to you. Your mobile phone should have all the information that a rescuer would need to help you. It is now a common practice to store all emergency contact numbers in cell phones, under the name *In Case of Emergency*, abbreviated as ICE 1, 2, 3, …, *n*. Any rescuer would then be able to lift the phone, look at the telephone numbers listed under ICE, notify the incident and bail you out of the problem.[1] Your mobile phone should have GPS included so that the rescuer can also provide your precise location when seeking assistance.

[1] Thanks to the imagination of a para-medic that it prompted East Anglian ambulance service to promote the culture of storing emergency contact numbers in mobile phones.

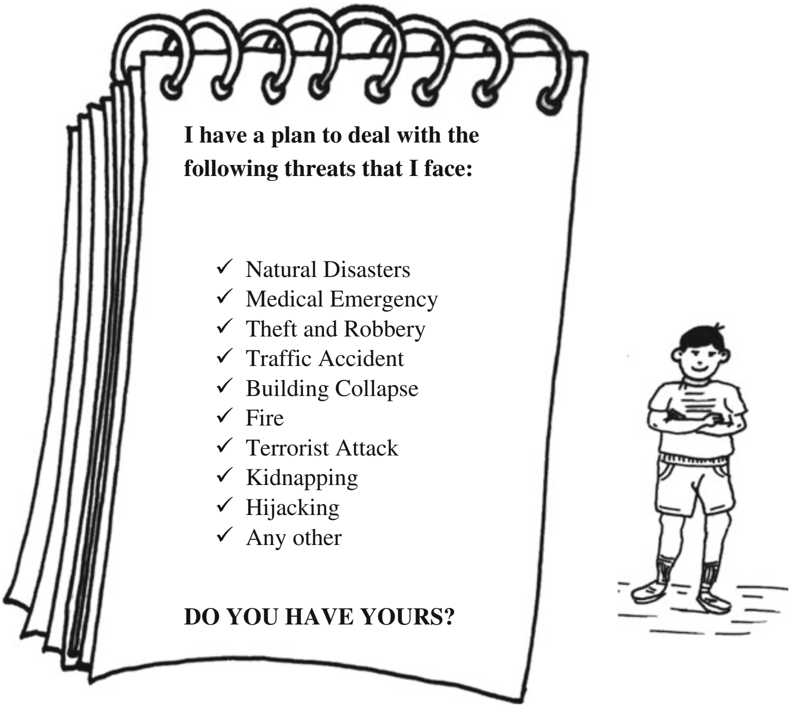


Fig. 8.1 A good personal safety plan is one which adequately covers all perceived threats and concerns individuals may face. Every effort must be made to develop capacity and survival skills to overcome the perceived threats

- Make culture of safety a way of your life, Fig. 8.2. Get training in personal safety, Fig. 8.3 and opportunity permitting an advanced level training to be of assistance to others, Fig. 8.4.
- Never forget to use helmets and safety belts while driving. For those who drive motorbikes, helmets must meet the highest standard of quality. NTT Docomo has introduced hi-tech multimedia helmets. These helmets have a built-in GPS receiver with high-speed connection, a camera in the front, and a miniature solar panel to power a lamp.
- Although most vehicles these days have much improved safety features and traffic rules are also very stringent, never forget to use safety belt as a matter of habit.
- Keep your *Go Bag* always ready at hand for easy pick in the event of an emergency evacuation. It is expected that a typical *Go Bag* will include all important documents, phone directories, a spare set of your important keys, personal medicines, a radio, a first-aid kit, a solar torch, a laptop and pen drives, a spare set of glasses, and money including some change. Arrange the bag in a

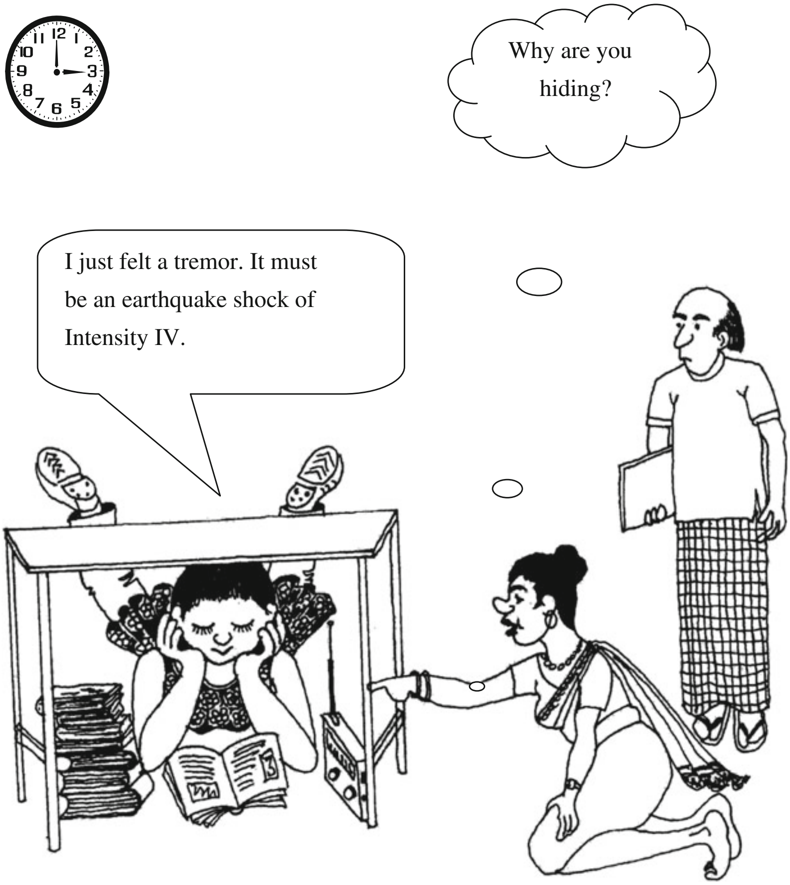


Fig. 8.2 Alertness is the greatest virtue and should become a part of our safety culture, our way of life, and our habit

manner that you know where is what, Fig. 8.5. Never wholly depend on electronic devices.

- Special care should be taken in managing passwords of bank accounts and credit cards. First and foremost, never disclose passwords to anybody. You should select at least eight-digit password which should be made of numerals and symbols and letters. That will give a hard time even to the hardened lock-breakers as it is never easy to try a few hundred of the 6 quadrillion possibilities.
- Ensure that you have a valid and adequate medical insurance cover, acceptable to all important hospitals. Run trial balloons to reaffirm this fact.

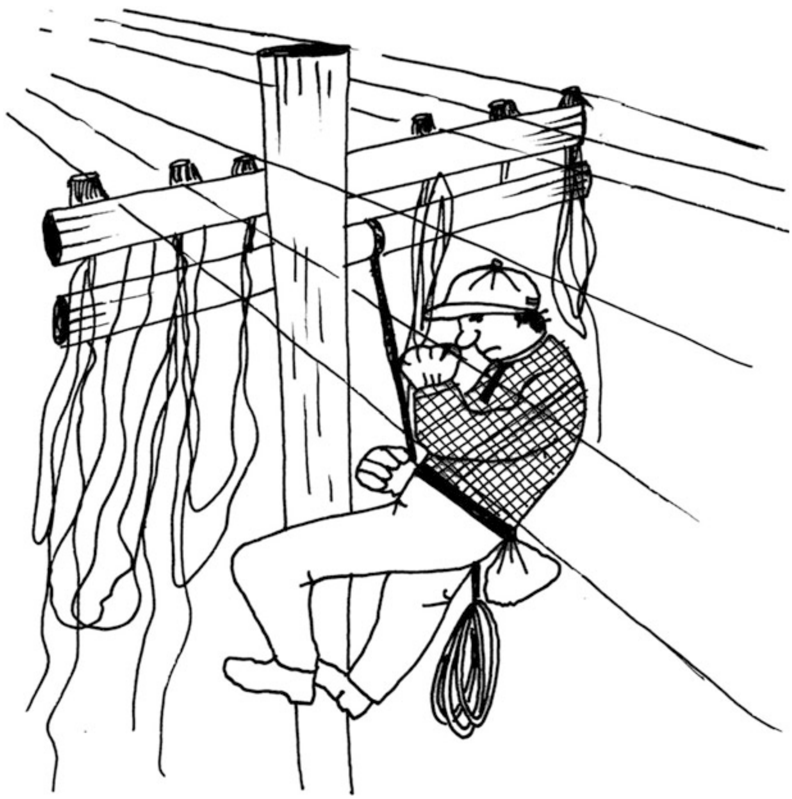


Fig. 8.3 A large number of us work on risky jobs without adequate training to face that risk. An untrained electrician runs the risk of death by electrocution. Training in basics of electricity and electrical appliances is very essential for each one of us regardless of whether or not that is our profession

- Savings other people's life in crisis times is your obligation but it is never wise to undertake rescue work without first ensuring your own safety. Mindless interventions with display of blind courage are foolish acts which may take an additional life, serving none, Fig. 8.6.
- Always back your personal, family, and office safety plans with a corresponding set of contingency plans and share all such plans appropriately. Disasters often come suddenly and crisis management seldom goes according to prelaid plans. You may have to adjust your plans according to the type of crisis at hand. In crisis times, things go wrong in the worst possible manner and one must be fully prepared to face uncertainties by taking recourse to a modified plan or a contingency plan in the event when the original plan fails.
- Stay cool, never create panic, and discourage rumors at all times. Your temperament, your strength of mind, and your positive thinking can be your savior

Fig. 8.4 Get trained and slowly step into the shoes of a leader. Training is not to be regarded as a one time affair but a life-long commitment. What we do will inspire people around us besides adding to our own safety? According to Jodi Rell "At the end of the day, the goals are simple: safety and security"

in a crisis situation when others in the same situation may perish when they lose their cool and succumb to rumors and panic.

- Shortcomings and mistakes are not always avoidable. Learn from mistakes and never make the same mistake twice. Experiencing troubles is normal in the world we live in. Some of you may have seen and survived disasters where others could not. Nothing could have taught you more than such experiences. You can survive many similar events in future if you vow not to make the same mistake twice!
- Always be alert, keep your eyes and ears open, and learn to deal with problems decisively, if and when they occur. When your eyes are open and you are alert, you will save yourself from falling into an open man-hole, while walking on a road. If you are an alert mountaineer, you may be able to protect yourself from a rapidly moving snow avalanche which may otherwise prove fatal.

Fig. 8.5 A *Go Bag* should be well organized so that you can readily retrieve what you need. The above picture is of a well meaning but a confused individual who has everything in his bag but does not know where is what? His pocket radio, spare solar-powered batteries, and antipollution mask seem to have got misplaced. His wife was, however, cool and pointed out to him that there was enough time left to buy the missing items

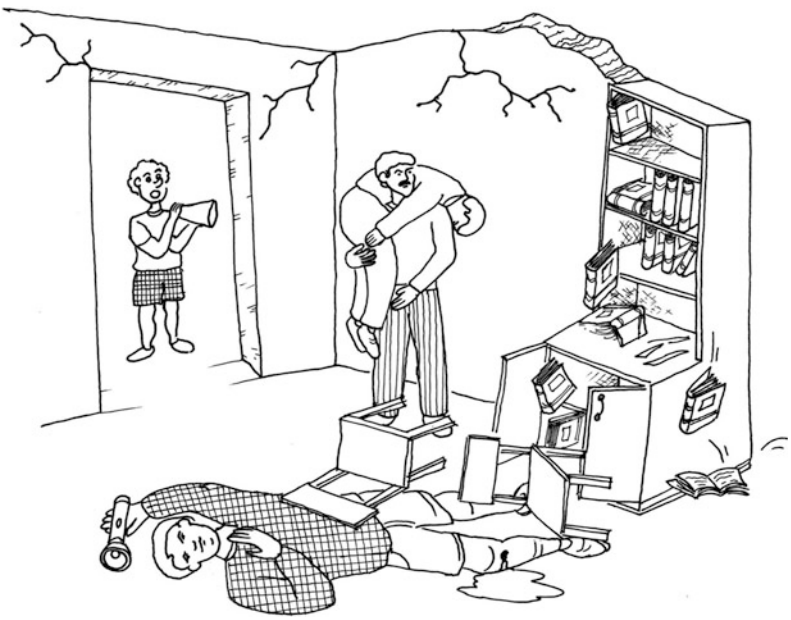


Fig. 8.6 The biggest lesson in personal safety is to ensure one's own safety before attempting to save the lives of other people; no matter your own kith and kin. Intense emotions in crisis times drive individuals in a close-knit family to often act foolishly at the expense of their own personal safety. One such foolish rescuer shown in the above picture (with a torch in his hand) was killed before he could rescue his uncle who was later rescued by someone else and hospitalized. Another foolish act is to try and picture risky situations like this without ensuring personal safety first

Guide to Safety at School

- Every school must have a school safety plan with particular reference to the anticipated hazards. It is useful to consult an expert for drawing a plan. Every student, teaching staff, and parents should be made aware of the plan, Figs. 8.7 and 8.8. No school plan can be successful without the ownership of all those for whom it is intended, Figs. 8.9 and 8.10.
- Students are highly vulnerable, because they are exposed to hazards at home, school, playground, swimming pool, gym, picnic and excursions, etc. First and foremost, all students must keep their parents and guardians fully informed of their movement plans, change of plans, and actual movements at all times and be familiar with the hazards they are likely to face wherever they go.
- Every student must wear identity card on person and keep a small pocket diary of key contact telephone numbers which must include telephone numbers of police, fire station, personal doctor, parents, and friends. This is particularly

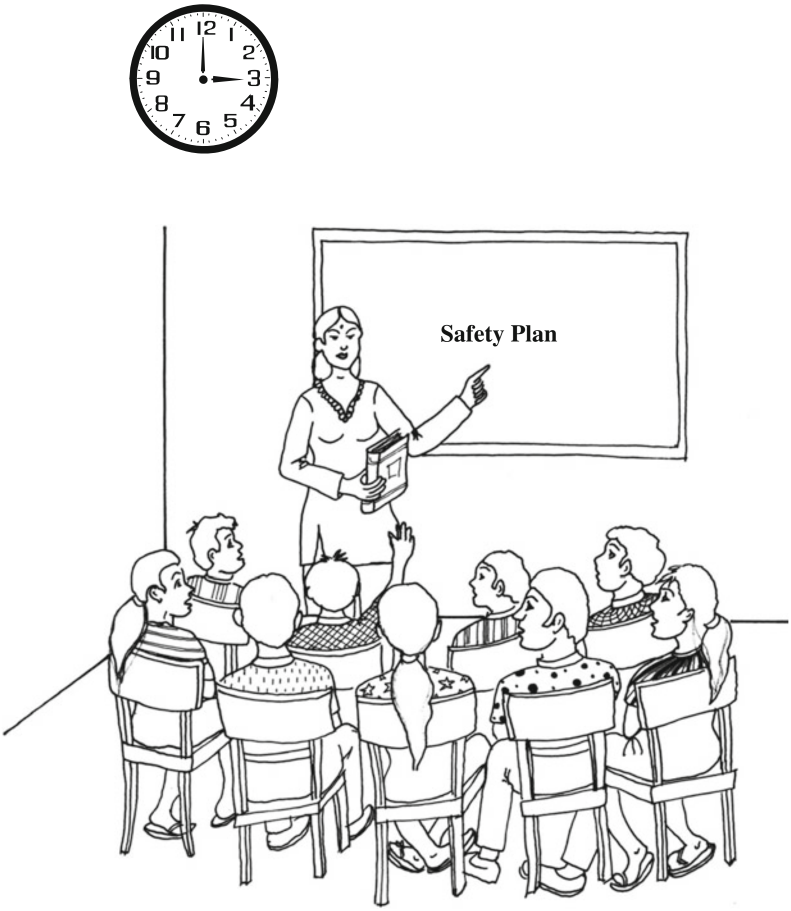


Fig. 8.7 Every school should have a school safety and emergency management plan. Teachers, parents, and students should be made aware of the plan with particular reference to the disaster risk reduction strategy

important when cell phones run out of their charge and one is required to use a public telephone. Any change of cell number should be quickly notified to all concerned, so that others are able to contact you.

- When placed in an emergency situation, no time should be lost in getting in touch with parents and guardians. It will be wise to find the nearest shelter and stay indoors to reduce exposure to risks and keep cool. Tough times do not last, tough people do.
- Every school must install CCTV to keep a check on the movement of people and conduct periodic mock drills.

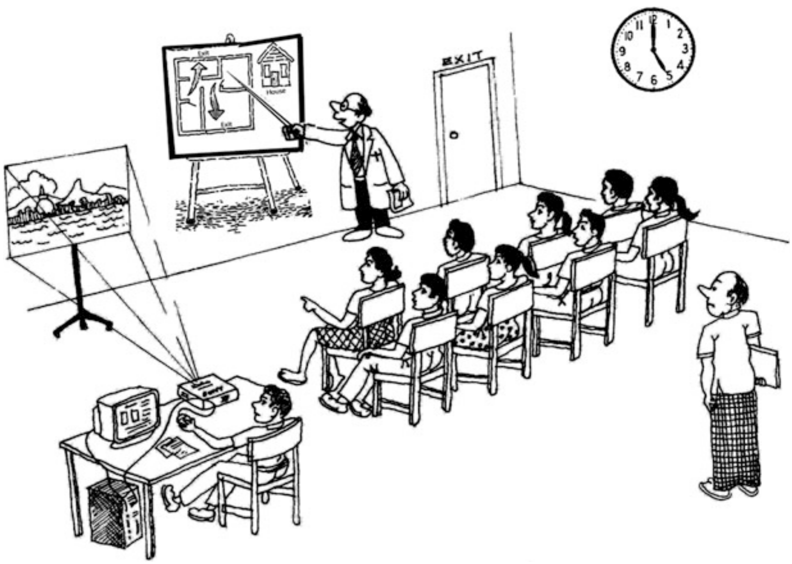


Fig. 8.8 Every single student is expected to proactively learn about the school safety plan and clear all doubts about every aspect of it. Even the best plans can be successful only when they are followed in letter and spirit

Fig. 8.9 No school disaster management plan can be successful unless it is owned by the school management, teachers, parents, other school employees, and the students. The above pictures showing affirmation of the plan relates to Sadhu Waswani International School for Girls in New Delhi

Fig. 8.10 A good disaster management plan must be matched with capacity building keeping in view the felt needs. A dedicated emergency management team established at the Sadhu Waswani International School for Girls is seen in the picture. Photos were taken by the author

- Avoid late night movements as far as possible, especially while in a place one is not familiar with. In case of an ambush or encounter with anti-social elements, it is never wise to pick quarrel.
- Always be receptive to the meetings between parents and teachers. Show school emergency plan to the parents and home emergency plan to the teachers. Read and follow both the plans carefully.
- Ensure that schools maintain a first-aid box and replenish its content from time to time. It must keep sufficient stock of medicines, torch batteries, water, and food, especially during an emergency time.

Guide to Safety at Home

- Every home must have a home safety plan with particular reference to the anticipated hazards. It is useful to consult an expert while planning. Every member of the family should be made aware of the plan.
- The building and its infrastructure including air-conditioning, electrical wiring, electrical appliances, and nonstructural elements should be hazard safe. Safety of buildings is particularly important for those who live in earthquake and cyclone prone areas, Fig. 8.11.
- Emergency contact telephone numbers including those of the nearest fire station, police station, and hospital should be prominently displayed closest to the house telephone, easily accessible to all, Table 8.1

Fig. 8.11 Every home should have a *home-safety plan* and every family member needs to know about it. It would be futile to realize the wisdom of this statement after the damage is done

- Every member of family should keep their respective *Go Bags* ready. Suddenly developed crisis situations hardly allow much time for picking the stuff not included in the *Go Bags*.
- Maintain a first-aid box and replenish its content from time to time. Training in first-aid is important for all family members.
- Keep sufficient stock of medicines, torch batteries, water, and food, especially during an emergency time.
- Install CCTV to keep a check on the movement of people, especially when no one is at home.
- Never leave the entry doors open.
- Every member of the family should be made aware of the escape route to be followed in the event of forced evacuation during an emergency. Ensure that the staircases and the corridors are not blocked.
- In case, you are asked to stay indoors in response to an emergency warning, for example, of a cyclone, store enough water, food, and medicine. Secure your doors and windows, Fig. 8.12.
- In case you have to leave your house to comply with the evacuation call, leave your contact telephone number behind so that your well-wishers can contact you, Fig. 8.13. Do not leave any information which, if in wrong hands, can harm you.

Table 8.1 Emergency information

	*Police*	
	Contact telephone:	xxxxxxxxxxxxx
	Nearest police post address:	xxxxxxxxxxxxx
	*Fire*	
	Contact telephone:	xxxxxxxxxxxxx
	Nearest fire station address:	xxxxxxxxxxxxx
	*Building emergency*	
	Contact emergency manager:	xxxxxxxxxxxxx
	Contact deputy manager:	xxxxxxxxxxxxx
	*Medical emergency*	
	Telephone for ambulance:	xxxxxxxxxxxxx
	Hospital telephones:	xxxxxxxxxxxxx
	Nearest pharmacy:	xxxxxxxxxxxxx
	Nearest hospital address:	xxxxxxxxxxxxx
	*Evacuation*	
	Telephone team leader:	xxxxxxxxxxxxx
	Meeting point location:	xxxxxxxxxxxxx
	*Taxi*	
	Telephone taxi agency 1:	xxxxxxxxxxxxx
	Telephone taxi agency 1:	xxxxxxxxxxxxx

Fig. 8.12 In the preparation phase of an emergency, it is essential to store adequate food, water, and medicines. At locations where strong winds are feared, as for example, during cyclones, it is desirable to firmly secure doors and windows to prevent the entry of wind. The common practice of reinforcing glass windows with tape is currently being questioned because large pieces of flying glass held together by tape may prove to be more damaging

Tips for Parents and Teachers

- Parents and teachers should have frequent consultations on safety plans to develop common understanding of their respective roles and responsibilities in times of emergency. School authorities should continuously engage parents in arriving at school safety plans through multilateral consultations. Parents should make timely interventions to enrich the home and school safety plans and stay in close touch with the school authorities.
- Students should be put to test on the way they respond to emergencies and mock drills. They should be trained not to get panicky, never to spread rumors, and remain disciplined at all times.
- Parents and teachers know that students learn by the examples they set and the culture of safety they establish at home and school. Foundation of safety is laid in the classroom. When we cross a road despite the red light just because there is no traffic within sight, students will surely follow our bad example and may one day cross a road in red light and meet with an accident. When we use seat belt even when our drive is very short or if we carry an umbrella whenever there is a forecast for rain, students will do exactly what we do. When they see us wear our personal ID card, they too will do the same.

Fig. 8.13 Whenever you have to evacuate your home for reasons of emergency, stick a note on the outside of the front door stating your contact telephone numbers and email address. It will help local authorities and your well-wishers incase they want to touch base with you. It is never wise or safe to give more details especially about your address, plan, and movements as shown in the picture above. It is better to give text messages from your mobile phone to all those who matter to you

- It is not enough for parents and teachers to be familiar with the anticipated hazards they might face in their day-to-day lives. It is their responsibility to spread awareness about the plans they make and teach dos and don'ts. It is important to arouse curiosity in students to learn by asking questions rather than spoon-feed them with the bookish knowledge or deter them with fatal consequences, Fig. 8.14.

Guide to Safety at Work Place and Outdoors

- Familiarize yourself with the safety plan of your office and the nature of anticipated hazards. Learn about safety rules prescribed for public places like cinema halls and railway stations.
- Familiarize yourself with the evacuation route from the meeting point at the place of your work to the preferred destination. Ensure that the passage from the office exit to the evacuation meeting point is never blocked.

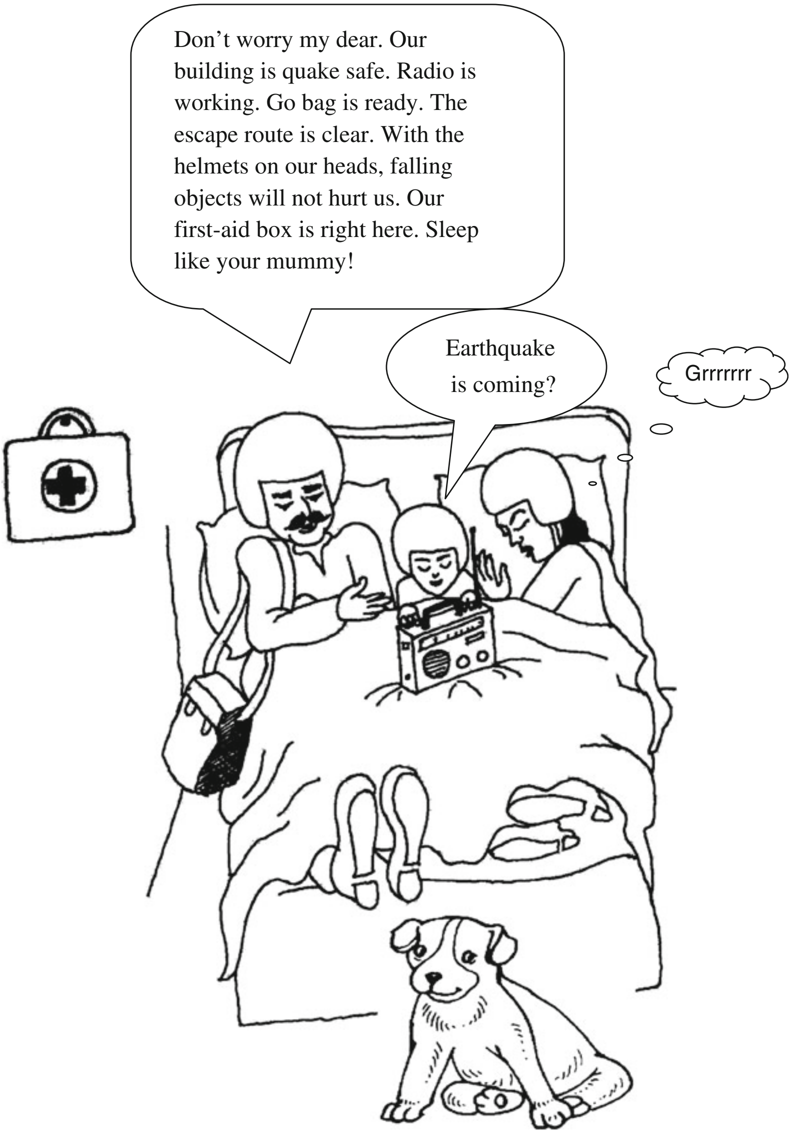


Fig. 8.14 Parents and teachers should remove the fear of disasters from the minds of the children

- Keep your *Go Bag* ready at all times to be able to respond to an emergency evacuation siren.
- Ensure that your office maintains a first-aid box and replenishes its content from time to time. Know well how to administer first-aid and how to extinguish small fires through use of firefighting equipment.

Fig. 8.15 Remain vigilant 24 × 7. You can avert disasters

- Ensure easy access to emergency contact numbers and familiarize yourself with the locations of the nearest fire station, police station, and hospital.
- Directory of employees and management along with emergency contact numbers must be made available to all the employees, and regularly updated.
- Keep sufficient stock of medicines, torch batteries, water, and food, especially during an emergency time.
- Install CCTV to keep a check on the movement of people, especially at critical points.
- Remain alert at all times especially while crossing the road, driving, or strolling at public places, Fig. 8.15.

Tips for Local Authorities

- Discipline in public life should be ensured through enforcement of rule of law and public education. Bad examples breed indiscipline and harm the culture of safety, Figs. 8.16 and 8.17.

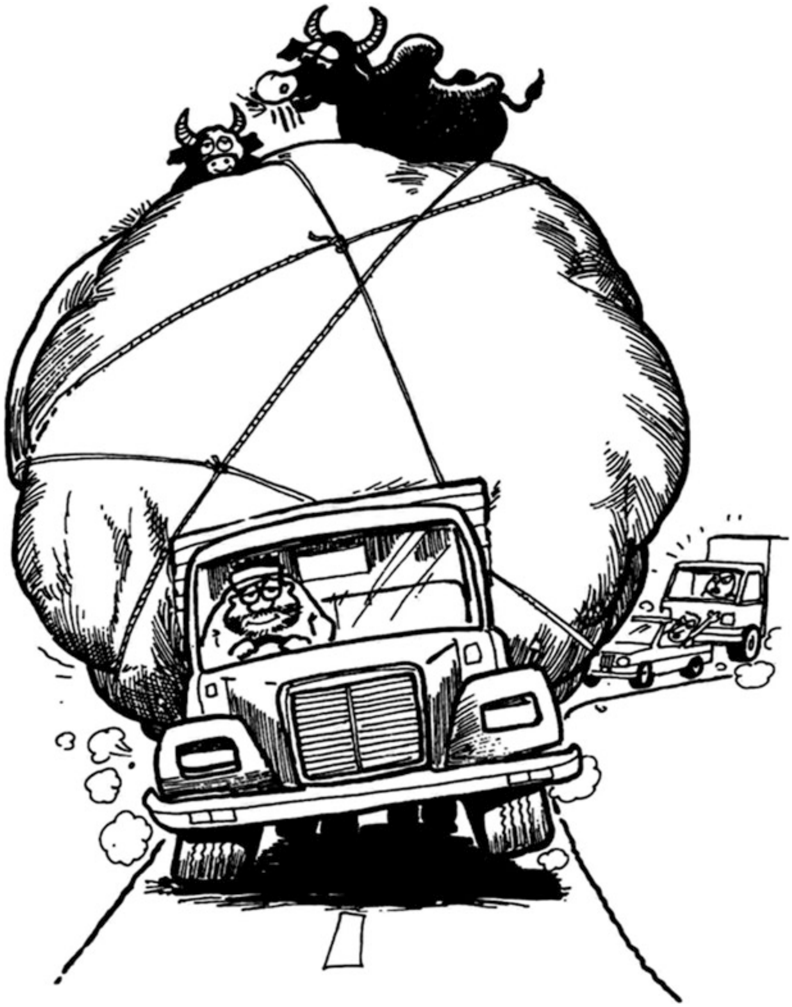


Fig. 8.16 Enforcement of traffic rule on a road with zero tolerance ought to be the responsibility of the traffic police. Also, as law abiding educated citizens, it is our duty not to flout the rules. Those who over-load their vehicles cause damage to the road, create traffic hazard, and set a very bad example for the younger generation. Cartoon by Murad Ali Baig reproduced with the permission of the Swagat Magazine

Fig. 8.17 An example of bad governance. When such avoidable road blocks are bad enough in the peacetimes, one shudders to think what that might mean in the emergency times. Cartoon by Murad Ali Baig reproduced with the permission of the Swagat Magazine

- Wherever a project activity like construction is in progress, public should be kept informed of the activity and of the associated hazards, Table 8.2.
- Cooperation of public should be sought to improve governance. Training camps should be organized to educate people in the art of reporting the ground situation at the site of an accident, Figs. 8.18 and 8.19.

Table 8.2 Let the people know what is going on the project out here?

Basic information	
Construction project ID	xxxxxxxxxxxxxxxxxxxxxx
Builders	xxxxxxxxxxxxxxxxxxxxxx
Contact telephone and address	xxxxxxxxxxxxxxxxxxxxxx
Date of start	xxxxxxxxxxxxxxxxxxxxxx
Date of completion	xxxxxxxxxxxxxxxxxxxxxx
Compliance of safety regulations	
To anonymously report unsafe conditions at the construction site call……… xxxxxxxxxxxxxxxxxxxxxx	
Staff and workmen	Fully equipped and trained
Hard hats and safety glasses	Project personnel and visitors
Project personnel insurance	Validated
Certification of equipment	Last validated on…………
First-aid and medicare kit	Last replenished on…….
Fire protection and safety drill	Next drill on………………..
Request your cooperation	
Entry to construction area	Permission essential
Hard hats and safety glasses	Mandatory
Follow instructions and be alert	Look for moving vehicles, falling objects and sign boards

- National authorities should provide unique emergency contact telephone numbers valid throughout the country. The New Delhi metro ask people to dial 100 for Police, 101 for Fire Brigade, 102 and 1099 for Ambulance, 1075 for Epidemics, and 1071 for helpline in the event of disasters. So many numbers are not easy to recall at the time of emergency and further difficulties would arise if they are not applicable in other parts of India. New York administration asks people to remember 911 for all emergencies and 311 to get easy access to all New York City government services with extreme of courtesy. Moreover, access to number 311 is available in over 50 languages.

Guide to Earthquake Safety

General Tips

- Know the earthquake history of the region you live in. Find out the official assessments of the level of earthquake hazard you face and share this knowledge with your relatives and friends. Develop and rehearse your household emergency plan and have an emergency survival kit of essential documents,

Fig. 8.18 Reporting of an incident to police is an art. One must ensure that all essential information is conveyed as clearly as possible in the briefest possible manner. Additional information should be provided only when questioned

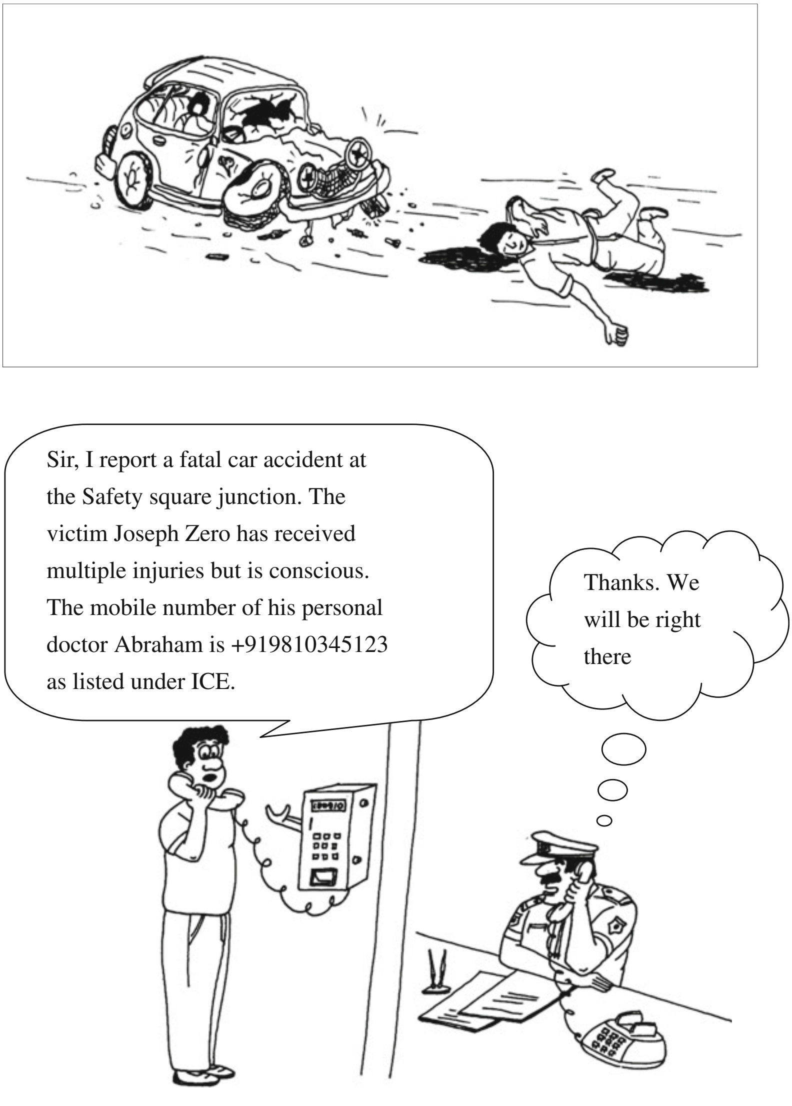


Fig. 8.19 Your ID card and information listed under incase of emergency (ICE) can save your life

money, and medicines always handy to escape with. Go through a formal or informal awareness program with an earthquake expert.

- Earthquake safety chiefly depends on the safety of the buildings we live in and the safety of the infrastructure we use. Consult an earthquake specialist to ensure that the building in which you live is earthquake resistant and collapse safe. If not, have the building retrofitted.

- Familiarize yourself with the emergency plan of the place you work and school emergency plan of the school where your kids study. Your home, children's school, and office may all get affected during an earthquake. Be alert about the evacuation routes and ensure that the passage to the evacuation point is never blocked.
- Ensure that all objects (photo frames, television, refrigerator, overhead lighting, false ceiling tiles, ducts, bookshelves, tall and heavy furniture, etc.,) in your house and in your office are so firmly secured that they do not fall down to hurt or kill in the event of an earthquake.

Earthquake Safety While at Home

- When an earthquake strikes, you should not panic regardless of the situation you are placed in and carefully and coolly plan out your moves making use of every tip you know.
- Waste no time in collecting your belongings. Rush toward open areas with your *Go Bag* and assist your family members only after ensuring your own personal safety.
- If you are already near an exit, quickly move out of the building to a location away from the buildings, walls, trees, narrow streets, power lines, etc. If you are away from the exit, drop, find a safe cover, and hold firmly on to it. If you are in a lift, stop at the nearest floor and take the safest (not necessarily the shortest) route to the exit. If you are sleeping, protect your head with a pillow, or go under the bed.
- Switch off gas stove, refrigerator, heater, geyser, air conditioner, and other electricity appliances.
- Stay away from glass panels, windows, overhead cupboards, and heavy objects.
- Give short text messages to your nearest kith and kin and listen to the radio and follow instructions there on.

Earthquake Safety While in a Hospital Building

- Follow the instruction of the hospital emergency management authorities with which you are expected to be familiar. Enquire about the hospital emergency plan.
- After ensuring your personal safety, try to alert and encourage other patients to move toward the nearest open place. Do not block their passage. Help physically challenged people, patients, women, children, and senior citizens on priority.

Earthquake Safety While in a Public Building

- Follow the announcements and the instructions given by the designated emergency managers.
- If no instructions are forthcoming, go out to the open area through the emergency exit. Never obstruct the staircase and emergency exit as a consideration for others.
- Help others to exit who are in search of emergency exits, without risking your own life.
- If you are in a lift, stop it at the nearest floor and get out of the lift and then the building.
- Do not stand in front of plaza and the building since brick, glass, plasters, and debris may fall and hurt you.

Encounter with an Earthquake While in an Open Space

- Avoid standing in front of tall buildings, walls, power lines, and other objects that could fall. Move away from trees, which too may fall.
- Drop to the ground and stay there until the shaking stops.
- If you are in a mountainous area or near unstable slopes or cliffs keep away from falling rocks and debris.
- Do not run through narrow streets.
- Do not return to your building until you are sure of its safety because the damaged building may well be unsafe under aftershocks.

Encounter with an Earthquake While in a Vehicle

- Stop in an open location away from buildings and stay there with your seatbelt fastened until the shaking stops.
- Do not continue driving because aftershocks may shake the ground again.
- Do not stop your vehicles on embankments, bridges, or ramps which may fail or suffer damage due to the quake.

Concept of Zero Tolerance in Earthquake Safety

"Earthquakes do not kill people. Bad buildings kill them."[2] It is one of the most profound statements of great living significance. Most of the losses due to earthquakes are because of collapse of buildings. Therefore, zero tolerance against building failures should become our life-long commitment. Buildings usually fail

[2] The statement is attributed to John Mutter, a seismologist at the Columbia University's Earth Institute, USA.

when they are either inadequately designed or poorly built. Architects and builders are squarely responsible for these lapses, and there should be stringent laws to ensure safe buildings.

Some 4,000 years ago King Hammurabi gave us the concept of zero tolerance. He evolved a set of 282 all-inclusive Codes of Law, of which the following six were exclusively devoted to construction. It was enforced in Babylonia, in the state of Mesopotamia, now the Southern Iraq. We recall this as Codex Hammurabi (c. 1792–1750 BC)[3]—also known as *The Code of Hammurabi*.

1. Law 228: If a builder has built a house for a man, and finished it, he shall pay him a fee of two shekels of silver, for each SAR built as his wage.
2. Law 229: If a builder does not construct a house well and it falls and kills the owner, then the builder shall be put to death.
3. Law 230: If the owner's son is killed, the builder's son shall be put to death.
4. Law 231: If the owners slave is killed, the builder shall pay the owner, slave for slave.
5. Law 232: If it ruins goods, the builder shall compensate the owner for all that has been ruined, and shall re-erect the house at his own expense.
6. Law 233: If the walls of an incomplete house collapse, the builder shall rebuild the walls at his own expense.

So ruthless was his implementation of codes that he created about 8-foot-high stela of black diorite and engraved the codes on it. These were for everyone to see and so much so that he himself had no authority to change any one of the laws. He accepted no excuses, explanations, and justifications making his *an eye for an eye* approach abundantly clear. He did not even spare those who were unable to read. Those interested to see the stela should visit Louvre Museum in Paris.

Sound building codes and stricter implementation continue to be on our wish list for decades on end. Whereas we have been successful in evolving the whole range of building codes in many parts of the world, the ultimate success in achieving earthquake safe buildings still eludes us because of our weak implementation of the codes. An Indian politician, Jagmohan, responding to deaths due to collapse of buildings in a disaster remarked that "when the foundation is of a poor quality made of spurious material which is infested with white ants from within, a gale of low intensity is sufficient to bring the edifice down, a hurricane is not needed." It is time to ask the question why 500- to 700-year old earthen buildings are still standing among the ruins of new buildings?

[3] *Source*: Johns (1904).

We need to spread awareness about the importance of the codes, tighten the legal regime, provide teeth to code implementation, remove governance deficit, and add accountability at all levels. How right John Ruskin was when he said that "when we build, let us think that we build forever. Let it be such work as our descendants will thank us for."

Lessons in Earthquake Safety of Buildings

What Do We Mean by an Earthquake Safe Building?

Earthquake safe buildings are those which resist moderate intensity of earthquake shaking without causing any structural damage, and would not collapse even under large intensity of earthquake shaking. Since a truly earthquake-proof building will otherwise be prohibitively expensive, and unaffordable, some damage to the building is accepted by design.

What Causes Building Failures During an Earthquake?

Earthquakes after earthquakes have shown that nonengineered buildings usually fall to earthquakes. Flouting of building design codes, failure to factor uncertainties in building design, exposure of buildings to unanticipated extreme earthquake-loading conditions, wrong choice and poor quality of building materials, defective construction, corrosion of reinforcement, and poor maintenance are some of the main causes of building failures.

Which Types of Buildings are More Vulnerable to Damage During an Earthquake?

Stone masonry and brick masonry buildings are highly vulnerable and susceptible to damage. Adobe buildings on firm or well-compacted ground too are vulnerable to ground shaking. On the other hand, reinforced concrete buildings are least vulnerable to earthquake damage. Wooden constructions are the most suitable because wood has higher strength per unit weight. It must, however, be remembered that use of timber in buildings makes them vulnerable to fire hazards.

What can be Done to Ensure Building Safety?

All new buildings should be designed and built strictly according to the building codes extant. All old and inadequately designed earthquake unsafe buildings should be appropriately strengthened, Figs. 8.20, 8.21, and 8.22. Buildings which have outlived their minimum levels of safety and utility should be demolished and rebuilt.

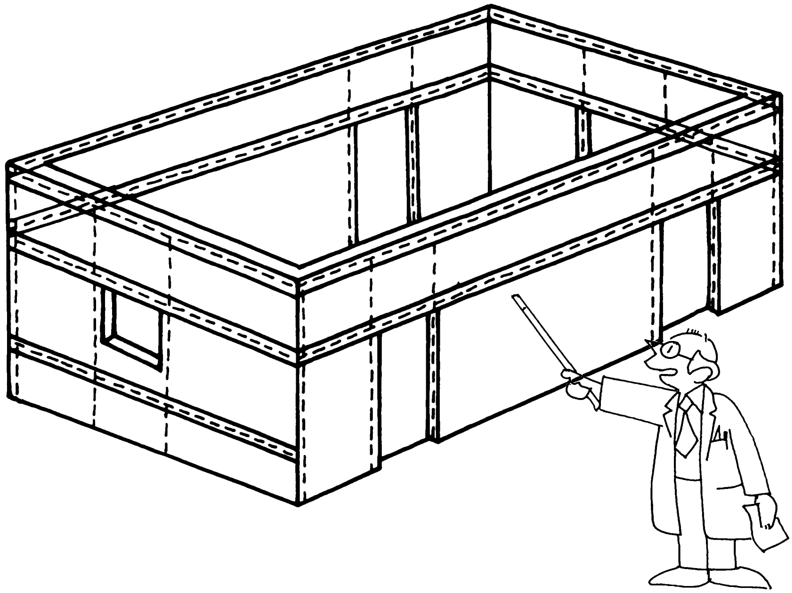


Fig. 8.20 Buildings are designed to withstand earthquake forces without causing collapse of any of its parts including the foundation. Parts of a building are held together by constructing beams at sill, window, and roof levels, to improve its seismic response

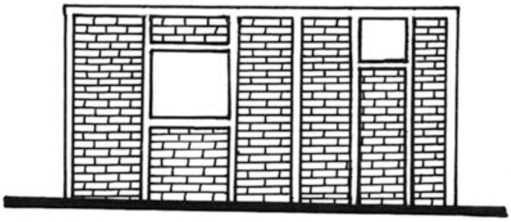


Fig. 8.21 An unconfined brick wall is not earthquake safe, because it fails to respond to the earthquake motion and move with it. The same brick wall can be made safer if we confine the masonry as shown in the figure above

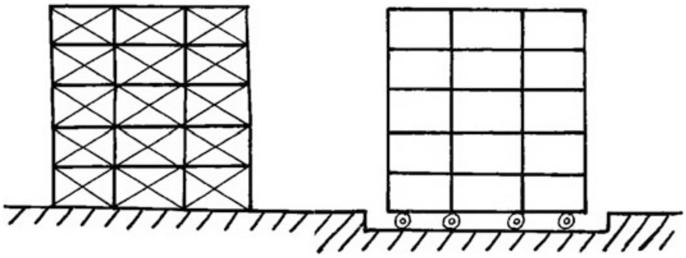


Fig. 8.22 There are number of other ways in which buildings could be made seismic-safe. For example, by bracing the building or by seismic base isolation. Base isolation is done to isolate the building from the ground so that it can efficiently respond to earthquake forces

What are the Lessons Learned?

– Avoid building on weak soils highly prone to failure during an earthquake

No building can be safe if its foundation and the ground beneath it fail due to an earthquake. In other words, earthquakes knock down even structurally sound buildings when their foundations or soil beneath them fail. And a building foundation may fail in a variety of ways. It may excessively move, settle, and tilt because of the failure of ground beneath it. Simply explained, earthquakes are known to cause ground failures because of soil liquefaction. Certain types of foundations such as isolated shallow footings are most vulnerable than deep foundations, especially when they sit on soils prone to liquefaction.

– Avoid odd and irregular building shapes

Shape of a building, usually defined in terms of its regularity and symmetry, forms an important consideration in its design for safety. Most of us are very familiar with buildings rectangular in shape, both in plan and elevation, looking like boxes. Then there are buildings having plans with shapes like, L, U, T, E, and Y, irregular in shape, looking like buildings with wings. When subjected to earthquake forces, regular, and symmetrical buildings behave much better than irregular and unsymmetrical buildings because irregularly shaped buildings tend to twist as they shake, and get damaged. Irregular and unsymmetrical buildings should be designed to take care of torsional stresses. Building irregularities also make building designs complex and costly.

– Avoid heavy construction and make your building light

Buildings should be as light-weight as possible. Higher the building mass, larger will be the earthquake forces; force being a function of mass. This is the reason that the damage potential of buildings with heavy roofs and upper storeys is high.

– Avoid large wall openings

Openings in walls of a building, such as large size windows and doors, weaken their earthquake resistance and enhance their damage potential. Wherever and whenever large openings are required for functional or architectural reasons, special design provisions must be made to ensure structural integrity.

– Avoid building rigidity and ensure building ductility

An earthquake safe building is one which has enough ductility so that it will bend, sway, and deform without causing failure, when subjected to the earthquake forces. Buildings made of unreinforced adobe, bricks, random rubble stone masonry, or concrete blocks are most vulnerable to earthquakes because such buildings fail to take large deformations, and because the construction materials they are made of, themselves crack, being brittle. This is the reason that steel reinforcement is provided to add ductility to the otherwise brittle materials and components.

– Avoid poor quality of construction

Higher the quality assurance in construction and maintenance, safer are the buildings. Inadequacy of building design, poor quality of construction materials and construction, and neglect of building maintenance are known to make buildings earthquake unsafe.

– Avoid suspended ceilings and loosely held building fixtures

Building projections should be either avoided or engineered. Suspended ceilings, parapets, poorly bonded facial stones, loosely held building fixtures and such other objects may fall during an earthquake causing loss of life and injury. Where considered unavoidable, they should be securely tied to the main structure. It is also desirable to dispense with thick-ceiling plaster.

– Avoid placing tall buildings too close to one another

Tilting of tall buildings during an earthquake is quite common. When two neighboring tall buildings tilt, they may pound on each other so much, so that the roof of the shorter building may hit the columns of the tall building, placing added load for which they were never designed.

– Avoid structural stiffness variability between building floors.

The variability in the structural stiffness of a building from one floor to the other should be avoided in order to reduce its damage potential. In other words, the higher the variability in the building stiffness along the vertical direction, the greater would be its damage potential. It is a sound engineering practice to let the columns of shear walls run continuously from the foundation to the roof.

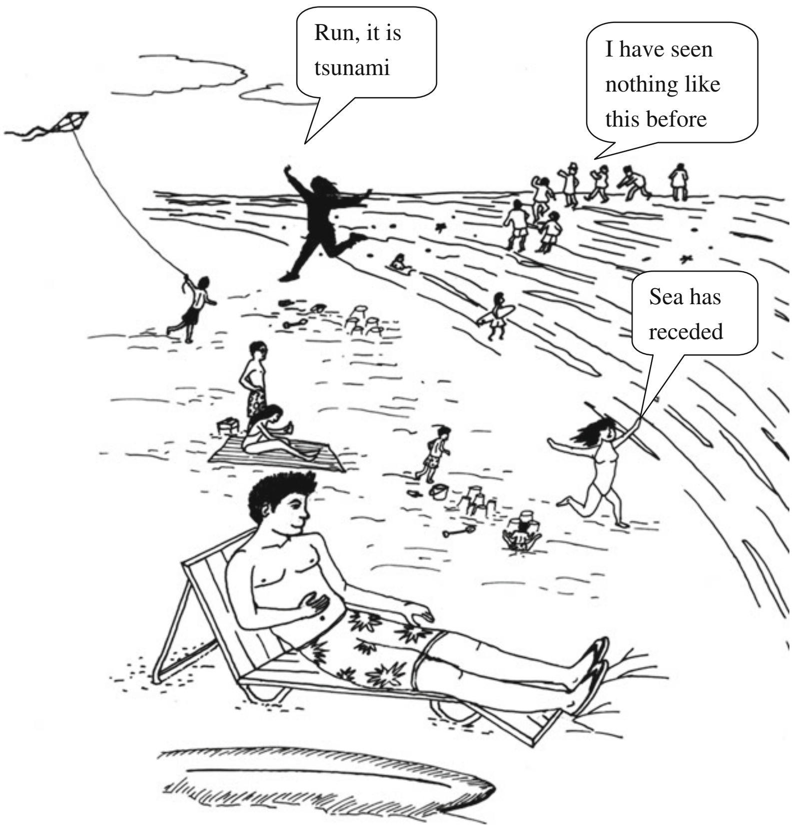


Fig. 8.23 Receding seawater is an indicator of an impending tsunami. This simple knowledge helped a British School girl Tilly Smith, holidaying on a beach in Thailand, to alert people of the incoming Indian Ocean Tsunami of December 2004. Many lives were saved because of her alert which made timely escape to higher elevations possible

Guide to Safety Against Tsunamis

- Tsunamis are feared most when an earthquake focus is located underneath an ocean or in its neighborhood. Any occurrence of a massive earthquake or a massive underwater landslide in the oceanic regions of the world should therefore be taken as tsunami alert.
- Glaring rise or fall (receding) of coastal waters and the associated roaring sounds often provide premonition of an approaching tsunami. Never ignore this signal, Fig. 8.23.
- Strike of a tsunami under the cover of darkness is the worst thing that can happen. People familiar with the roaring sounds of tsunamis have been successful whistle blowers.

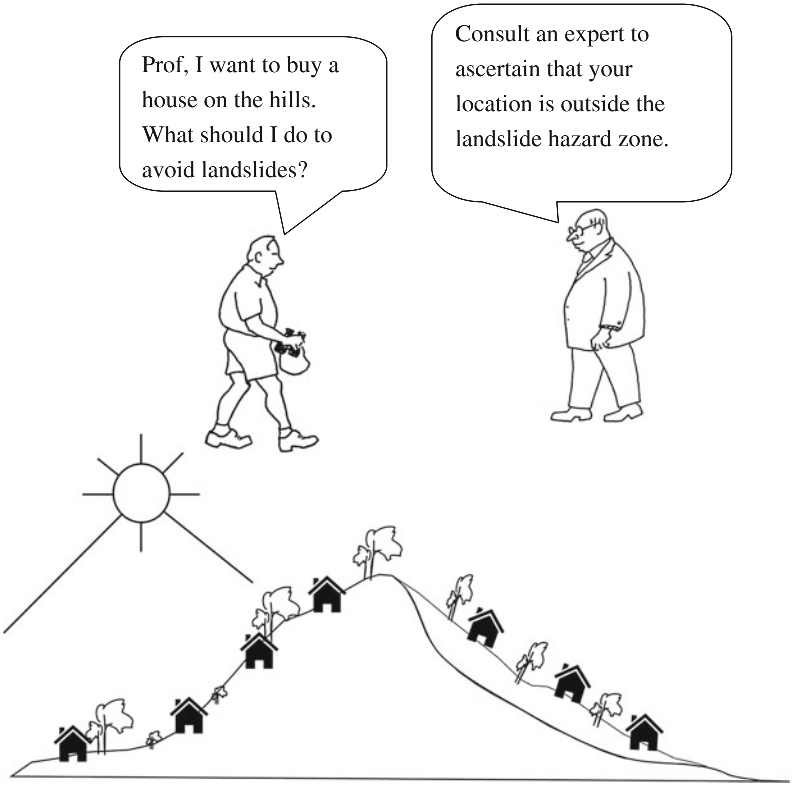
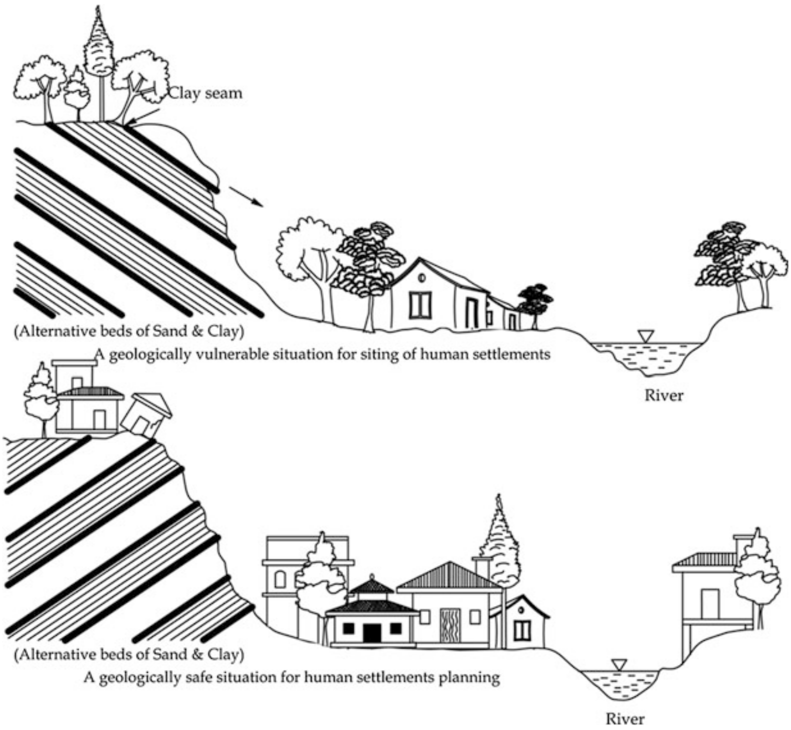


Fig. 8.24 Always buy a house on the sunny side of the hill. The opposite side is more prone to landslides. Refer to the landslide hazard map of the area to stay out of the high landslide hazard zone. A well-drained slope with favorable geology is generally safe

- A fast incoming tsunami will leave no room for you to escape. Waste no time in moving on to a higher elevation away from the coastline. Do not waste a second in trying to collect your valuables which may well be at the expense of your own life.
- Although buildings in low-lying coastal areas are rarely safe, it may not be a bad idea to move on to the top of nearby tallest building, if there is no time to escape on to higher elevations inland.
- When in a boat, it may be wise to move away from the coast toward deep sea. Be sure that the tsunami has passed off before returning to the coast.

Guide to Safety Against Landslides

- People living in the landslide prone areas must consult a specialist to find out how safe are their houses, Fig. 8.24. It is useful to be familiar with the landslide hazard zonation map of the area to know more about the degree of landslide hazard you face. For more clarity on degree of landslide hazard of the area you live, ask for a user-friendly large scale landslide hazard map.
- Townships located on poorly drained slopes with unfavorable geology are unsafe, Fig. 8.25. People living on fragile mountains, especially near the bottom of problematic slopes or in the hilly areas threatened by monsoonal rains and earthquakes are generally exposed to even higher orders of landslide hazards. Because of the population explosion, mindless urbanization, and paucity of land, people are gradually moving on to unsafe areas. It is important, therefore, to take corrective measures, be vigilant, and respond to early warning. Figure 8.26 shows well-engineered construction on slopes in a landslide prone area.
- Some of the landslides, especially mudflows, debris flow, and earth flows can travel long distances before coming to rest. Since they are very expensive to control, it is also common to let flows take place in a manner that the safety of the infrastructure is not harmed, Fig. 8.27.
- It is always advisable to permanently fix landslides rather than attend to them from time to time by piece-meal corrective action. One of the finest examples of this is fixing of a century old landslide at Watawala in Sri Lanka. No one can believe now that that was once a massive landslide. Figures 8.28 and 8.29 show the slide area before and after fixing the landslide.
- Most of the landslides tend to show signs of early warning. For example, excessive subsidence of ground, back-tilting, or forward tilting of trees and vertical poles, development of cracks on the floors and walls of buildings, lateral movement of objects on slopes, sudden appearance or disappearance of ground water and falling of boulders often precede a landslide. The training of public in the art of field observations is therefore critical to landslide safety.
- Protection of deep cuttings, whether behind a hill house or on the road, is most essential. This is because a cutting which is safe today may be quite unsafe after sometime due to progressive failure. Anchoring of slopes is one of the common remedies, Fig. 8.30. One of the good examples of slope stabilization using prestressed rock anchors at Khunni Nala in the State of Kashmir in India is shown in Fig. 8.31.



Look for a favorable Geology. Bed of layered rocks dipping toward buildings is more prone to landsliding.

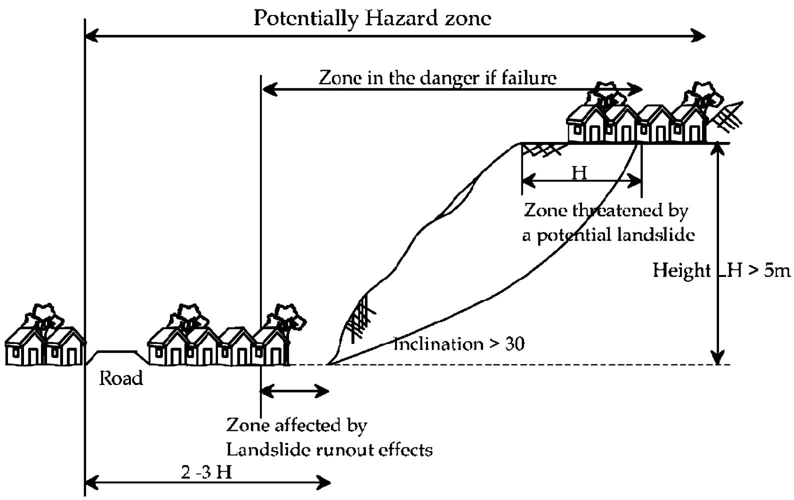
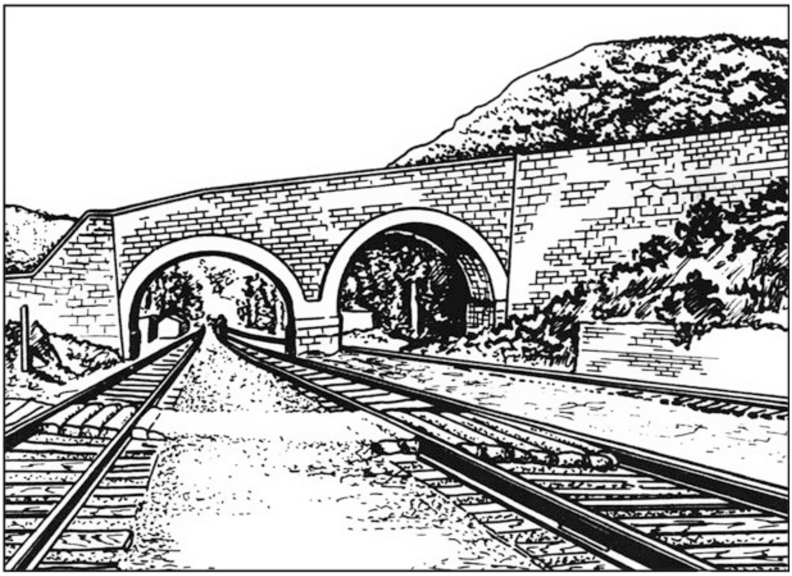


Fig. 8.25 Ensure that your house is neither too close to the *top* of the slope nor too close to the slope-*toe*. These two locations make buildings highly vulnerable to landslides

Fig. 8.26 The above pictures show examples of engineered townships against landslides. Planning of housing layout, use of design codes of practice, minimization of violence against slopes, protection of its vegetative cover and caring for its surface and subsurface drainage are some of the design features. The slope behavior will now depend on its drainage and maintenance



Sometimes landslides occur without affecting public utilities and therefore they fail to capture public imagination. In the above picture, the mudflow overflows the railway line. Overloading of the structure is countered by providing gradient in the range 8–15°. (*Source* picture by Korol'dov).

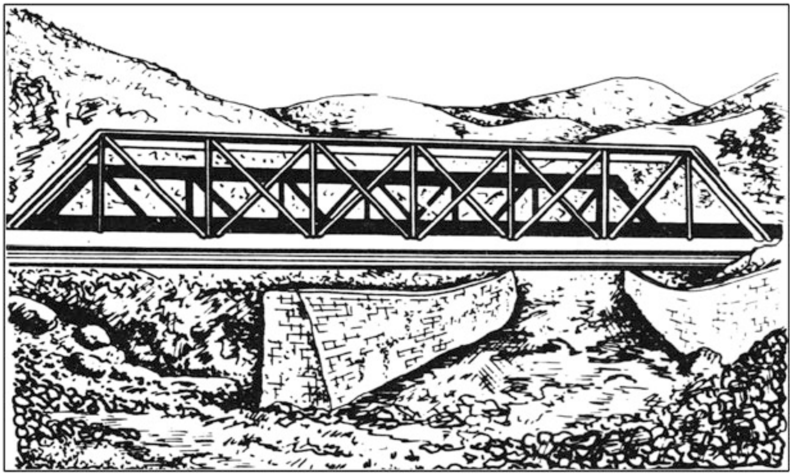


Fig. 8.27 In the above picture, a rapid motion debris flow is seen to pass underneath a bridge. (*Source* picture by Avaliani)

Fig. 8.28 The above picture is of the famous Watawala earthslide in Sri Lanka which affected a railway line for decades on end. On 3 June 1992, at about 5 a.m., the engine of the Hatton–Colombo goods train nose-dived and sunk disrupting the train services. Scarcely 1 h before this accident, had the Colombo–Badulla passenger train with 3,000 passengers passed the very same location

Fig. 8.29 The Watawala earthslide considered intractable in 1992 was fixed in 1995 jointly by the National Building Research Organization, Colombo, the Sri Lankan Railways, and UN-HABITAT taking recourse to one of the most carefully conducted scientific studies. The earthslide was stabilized using the technology of direction drilling to create a network of long and continuous self-actuated subsurface drains. So successful was the remediation program that Watawala earthslide is a history now

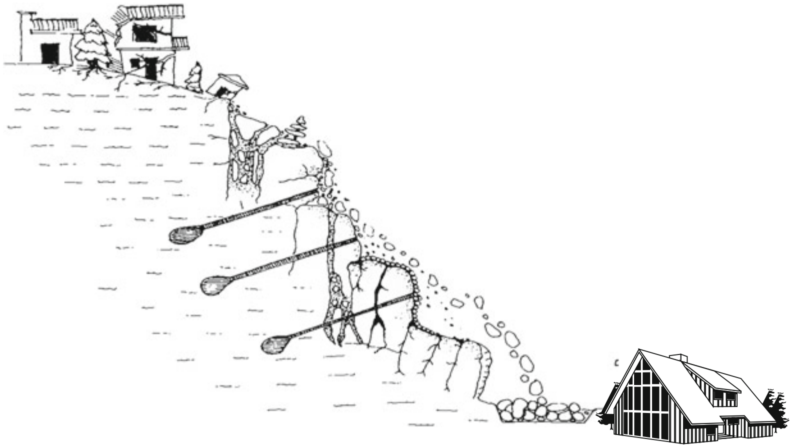
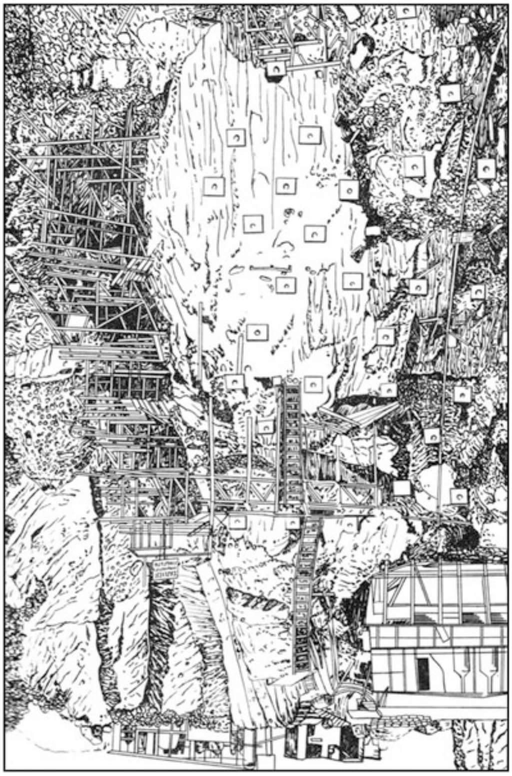


Fig. 8.30 Landslide control measures aim either at reducing the slide actuating forces or improving the slide stabilizing forces. Anchoring a slope as shown holds the jointed rock mass together thereby improving slope safety. The trench provided at the *bottom* of the slope is meant to receive the falling rocks so as to prevent them from hitting the hut at the *bottom* of the slope

Fig. 8.31 The picture shows the high slopes (1,200–1,600 m) of the Khunni Nala on the Jammu–Srinagar National Highway 1A between Ramban and Banihal in India which were stabilized by using prestressed anchoring. *Source* R. K. Bhandari (1988) landslides in the Himalaya and protection facilities. Chapter 12 of landslides and mudflows—a UNESCO–UNEP joint publication



Guide to Safety Against Cyclones

- Read the case-records and the eye-witness accounts of the historic devastating cyclones in your region and absorb the lessons learnt. This prior knowledge would make you better prepared to face future cyclones.
- Be familiar with the national, state, district, and local level cyclone disaster management plans and early warning systems as well as with the locations of emergency shelters meant to protect lives in the event of a severe cyclone. Identify the nearest cyclone shelter.
- Prepare and maintain emergency survival kit (*Go Bag*) incase you are evacuated. Stock enough dry food, water, and essential medicines if you were to stay indoors.
- Keep a watch on the developing weather and listen to the radio news, especially the announcements and alerts. Tune to your local TV for further information and warnings.
- Check that the walls, roof, and eaves of your home are secure. Close shutters and nail all windows. Secure all doors. Check your first-aid kit and store water.
- Keep emergency phone numbers accessible to all the members of the family.
- Ensure every member of your household knows which the strongest part of the house is and what to do in the event of a cyclone warning. Check that neighbors are aware of the situation and are also preparing.
- Fuel your vehicles and park them in a ready-to-go position.
- Do not venture into the sea for fishing.

Facing a Cyclone Warning

- All family members must assemble at a predetermined safe place as per the evacuation plan.
- All vehicles must be parked under solid shelter (hand brake on and in gear).
- Close shutters of all windows. Draw curtains and lock doors.
- Turn off power, gas, and water connections.
- Tune to your battery-operated radio for further information.
- If evacuating inland (out of town), take pets and leave early to avoid heavy traffic, flooding, and wind hazards.
- If evacuating to a public shelter or higher location, follow official instructions. Opportunity permitting, try to take warm clothes, essential medications, baby food, nappies, valuables, important papers, and documents in waterproof bags. Large/heavy valuables should be left behind well protected in a strong cupboard.

When at Home

- Follow the household cyclone emergency plan. Stay inside and shelter in the strongest part of the building.
- Disconnect all electrical appliances and turn off the gas.
- Listen to your battery radio for updates as power failure is likely.
- Keep emergency kit with you.
- If the water starts entering your building, protect yourself with mattresses, rugs, or blankets. Move to an elevated place.
- Do not forget your keys if you evacuate.
- Do not forget to switch off the power, water, and gas before leaving.

When Driving

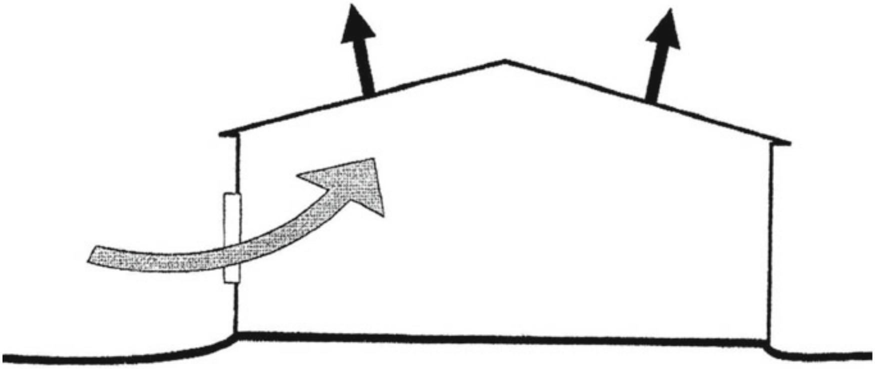
- Stop as far away from the sea as possible, clear of trees, power lines, and streams. Stay in the vehicle parked under a solid cover.
- Fuel your car if possible.

Post Cyclone Care

- Beware of the calm in the region of the 'eye' of the cyclone. If the wind suddenly drops, do not assume that the cyclone has passed over. Violent winds may soon resume from the opposite direction (it is best to wait for the official all-clear).
- Quickly return home remembering that the shortest route is not always the quickest because it may be unsafe. Beware of reptiles and snakes driven out of their homes.
- Do not stand near fallen power lines, damaged bridges, buildings, and trees.
- Continue to listen to your local radio for official warnings and advice.
- Do not go outdoors again until officially permitted.
- Do not use electrical appliances if wet. Check for gas leaks.
- Do not make avoidable long chat telephone calls to keep the communication system as free for official emergency use as possible.

Guide to Safety Against Thunderstorms and Lightning

- If you see lightning and then hear thunder of a storm even before you could count 30, it is a sure warning signal that you must rush indoors to protect yourselves, Fig. 8.33. Monitor thunderstorms and lightning from indoors. You should go out only after ensuring lull for at least 30 min since the last thunder.
- If no shelter is available close by, seek protection by getting into a hard-topped vehicle and shut its windows. You are much safer inside a car or a pipeline than outside because steel frame of a vehicle or pipeline protects but be careful not to touch the metal parts, Fig. 8.34.
- Keep a safe distance from isolated trees or isolated tall structures. Know that lightning can strike the same place twice and can spread out nearly 20 m after striking the ground.



Beware that failure of an opening on the windward side of a building can lift up and blow away the roof (Fig. 8.32).

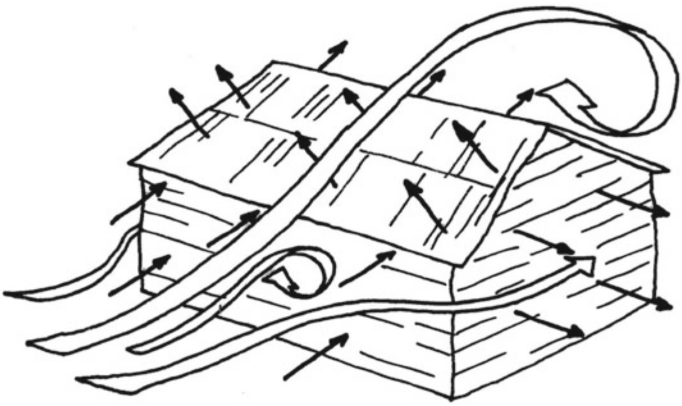


Fig. 8.32 If there are no openings on the windward side, wind pressures, and suction effects could persist around a building for several hours. Cyclones may prove very damaging when cyclonic winds create forces on the building beyond its capacity to sustain. (*Source* Mitigating natural disasters—phenomena, effects, and options. A UNDRO manual publication, 1991)

- If you get a tingling sensation or a standing hair experience, it is to be taken as a premonition of impending threat of lightning. In such a situation, quickly acquire the lowest profile by crouching down the balls of your feet but never make a mistake to lie flat on the ground.
- Lightning can affect a building in three ways
  (a) direct hit
  (b) through external wires and pipes, and
  (c) through the ground. Lightning can also travel through reinforcement in concrete walls, flooring, etc. Beware.
- Do not use wired phones. Mobile phones are the safest to use.

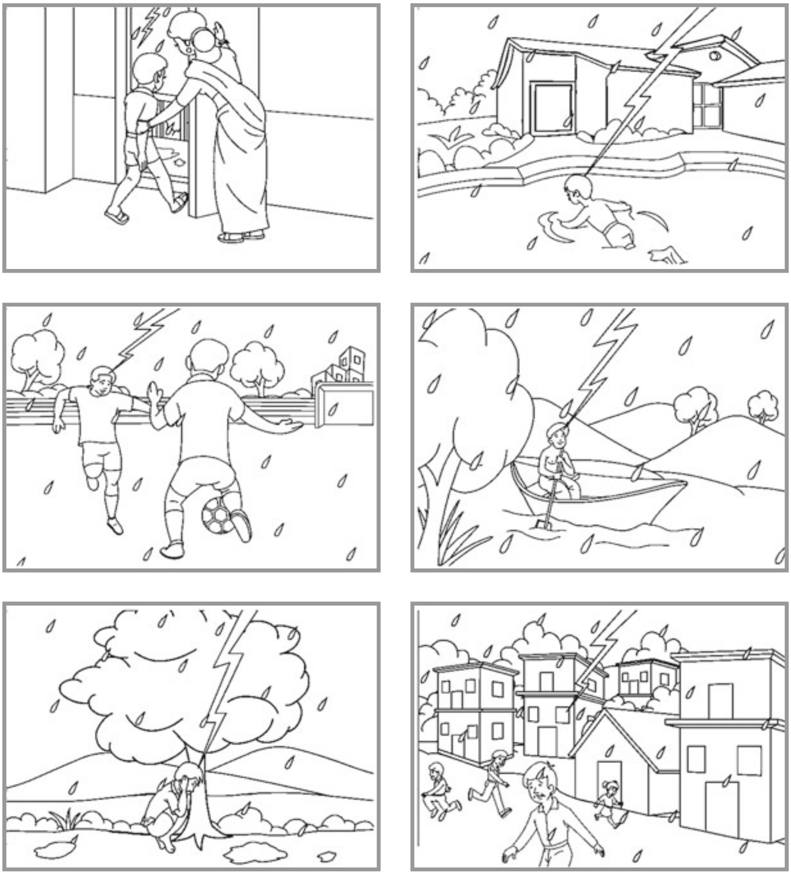


Fig. 8.33 The above set of pictures show what you should not do on a stormy day. Those who stay indoors, stay safe

- Unplug all the electrical and electronic equipment as soon as the thunder and lightning seem likely. Do not forget to disconnect radios and TVs from external antennas.
- Avoid taking a shower during thundering and lightning.
- No rain does not mean that no danger of lightning. Lightning may occur as far as 15 km from the nearest rainfall area. Be alert.
- Do not be under the mis-impression that the rubber shoes you wear and the rubber tyres of your car will protect you from lightning.
- If someone is struck by lightning, at once come to his or her rescue. It is a very wrong notion that those struck by lightning carry an electrical charge, Fig. 8.35.
- A lightning protection system or no lightning protection system, a lightning can always strike. A lightning protection system, however, ensures a low resistance

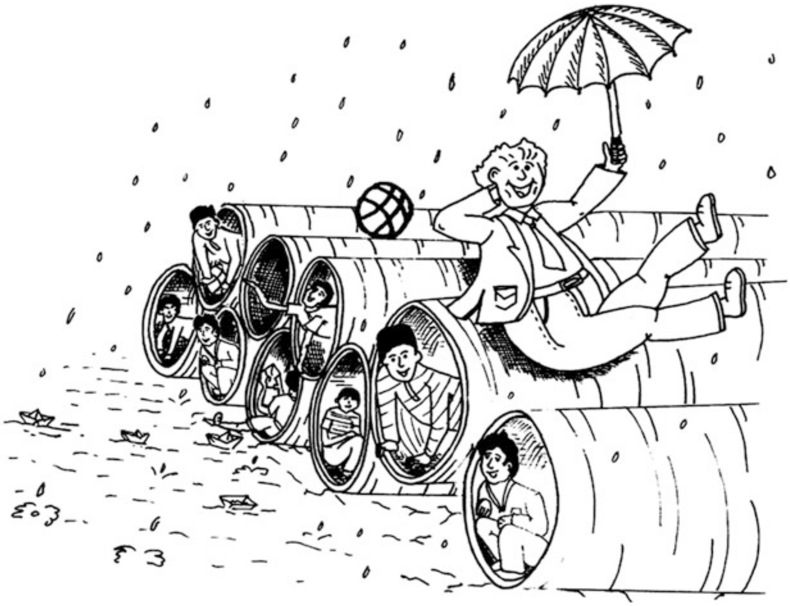


Fig. 8.34 The above picture shows a school party at picnic with students taking shelter in pipelines during a severe thunderstorm and lightning. The teacher appears totally unaware of the real threat of his getting killed by lightning

path for discharge of lightning energy. Good systems of protection carry lightning charge through lightning rods and cables from the building to the ground, and dissipate the charge. Ensure that the building is well protected.
- If any part of a building is hit by lightning, call fire department immediately. Check whether anybody is hurt.
- The immediate cause of death due to lightning in most cases is cardiac arrest. It is important, therefore, to check whether the victim is still breathing and has a pulse. Act accordingly.
- Loss of memory, dizziness, fatigue, chronic headache, or difficulty in sleeping could be the consequences of any sad lightning experience.

Guide to Safety Against Dust Storms

- Do not go outdoors even when invited by friends or relations. Driving is dangerous in a dust storm.
- If you are already driving, never stop on the road. If you cannot get off the road, proceed at a reduced speed. Sound your horn intermittently. Opportunity permitting, pull off the road and park. Make sure that all the lights of your vehicle are switched off when you park so as to reduce the possibility of rear end collision.

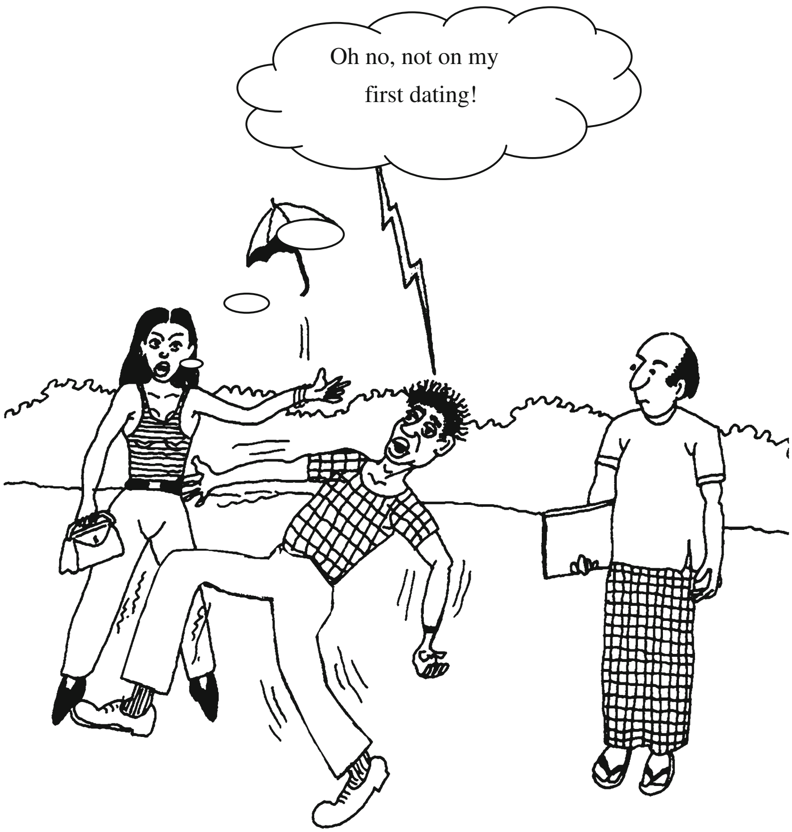


Fig. 8.35 If someone is struck by lightning, at once come to his or her rescue. It is a very wrong notion that those struck by lightning carry an electrical charge

- Roll up the windows and turn off vents that bring outside air in.
- If you must necessarily go out to attend to an emergency in a storm, carry a mask and an airtight goggles. If you do not have a mask, wrap a piece of cloth around your nose and mouth. Moisten it a bit. If you are already caught in a dust storm in an open area, assume storm protection position-bent over with torso resting on the upper legs and knees, head down with arms clasped over the lower head, Fig. 8.36.
- When in a group, join one another to make a small diameter human ring with heads looking down and hands clasped together. Dust storms being frequent in desert areas, people can be seen to face a dust storm by clasping together, Fig. 8.37.

Fig. 8.36 This is how you must rest low and protect your eyes when caught in a dust storm

- When indoors, switch off electricity and gas connections and move to the interior rooms.
- Rain frequently accompanies dust storms and will cause slippery conditions. Drivers must take a careful note of this.

Fig. 8.37 An artist's impression of women folk in Gujarat in India seen to face a dust storm by clasping together

Guide to Safety Against Floods

Before Flood

- Contact the local authorities to find out the historic floods in your locality and learn lessons toward ensuring future safety. Familiarize yourselves with the flood zonation map and the flood hazard rating of your area, Fig. 8.38.
- Get acquainted with the local level flood protection and emergency plan as also with the flood warning signs.
- Develop and rehearse your household emergency plan. Everyone in your family should know where to go when facing evacuation during an emergency. Everyone should know what to do incase any of the family members get separated. Jointly identify the nearest high ground where you can meet.
- Listen to the radio for weather forecast and flood level rise.
- Store your valuables and essential food and clothing above what you judge to be the high-water mark.

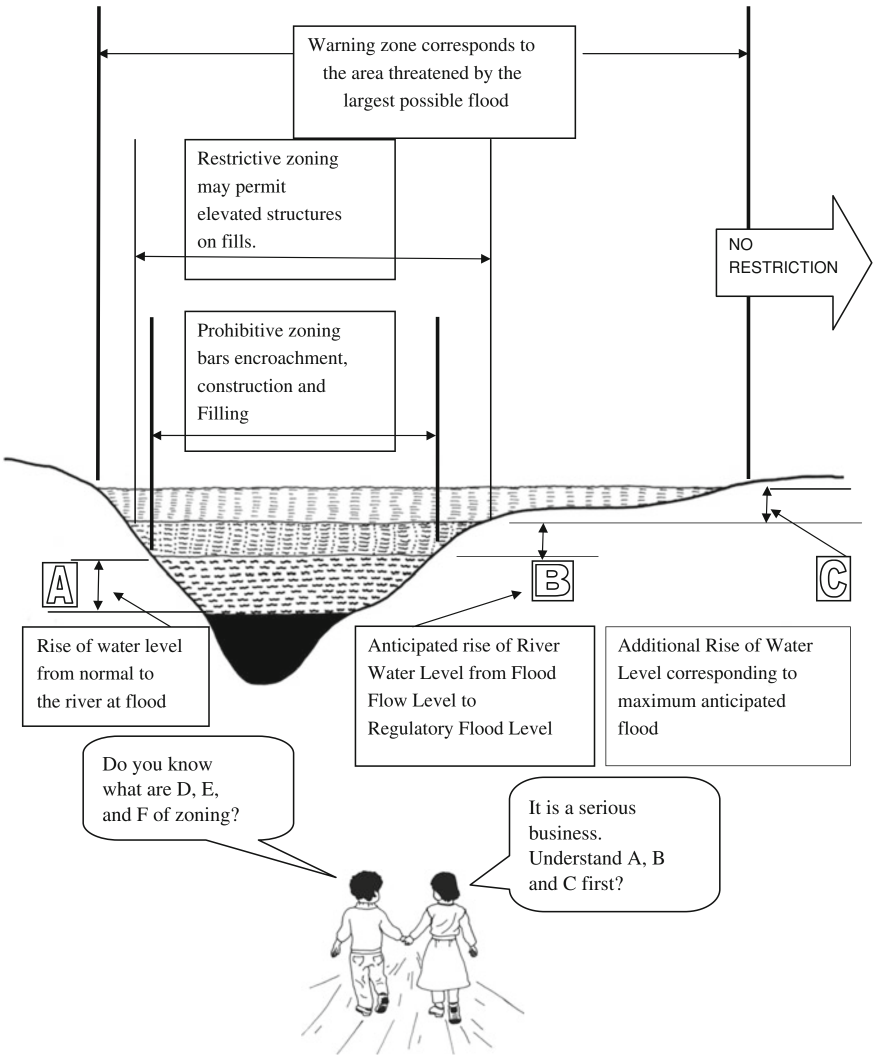


Fig. 8.38 Learn more about flood safety plan and guidelines

- Elevate the furnace, water heater, and electric panel if susceptible to flooding. Educate one and all in the family to turn off gas, electricity, and water well in advance of the flood warning.
- Install and maintain a sump pump system if you have below-grade floors to prevent backflow in sewer lines.
- Landscape the surrounding area with native plants and vegetation that resist soil erosion.
- Use water-resistant building materials in areas below the base flood elevation.

During Floods

- Follow the evacuation plan when your house gets flooded during a storm.
- Be aware of streams, drainage channels, and areas in the neighborhood known to flood suddenly and be prepared to face the floods.
- If instructed or considered necessary, turn off all utilities at the mains.
- If your vehicle gets caught in flood, abandon it; retrieve your belongings and move on to a higher ground without loss of time. Rapidly rising water may overflow the vehicle and threaten its occupants.
- If you have to walk in water, walk where the water is stationary and watch out for water animals—especially snakes and reptiles. Do not try to cross a flowing stream where water is above your knees. You run the risk of getting swept away by strong currents.

After Flood

- If needed, report to the nearest hospital. Keep a battery-powered radio with you so you can listen for emergency updates and news reports.
- Do not drink floodwater. It could be contaminated. Boil drinking water before using it. Well water should be tested for purity before use for drinking. If in doubt, call your local public health authority.
- If fresh or canned food has come in contact with flood waters, it is better not to consume it.
- Report broken utility lines to appropriate authorities.
- Consult an expert to restore flood damage to your building.
- Contact your local authority for cleaning up debris.
- Use the phone only to report life-threatening emergencies so that communication system is not over loaded.
- Do not touch any power lines and electrical wires.
- Do not visit flood disaster areas. Your presence might hamper rescue and other emergency operations.

Guide to Safety Against Fire Disasters

General Tips

- Study the fire safety and fire escape plans of your home, office, and other places you work, live, or visit. Determine escape routes in each case and rehearse on how to escape in the event of a fire. Everyone at home should know who to ring and at what telephone number, in the event of a fire.

- If you live in a flat in a multistoried building, locate the fire alarm call points on your floor. Also, it would help to know where the fire extinguishers are located and how they work. Position the extinguisher where you can get to it quickly.
- Minimize fire load in your house by ensuring that electrical wiring, fixtures, and fittings are hazard free. Never store combustible materials or use construction materials with low fire rating.
- Candles could be a fire hazard. Never leave a place without extinguishing candles and without shutting down the gas or electrical burners. Never put candles near curtains or other fabrics, or furniture, Fig. 8.39.
- Always keep corridors, exits, staircases, and passages free of obstacles so that people can escape if there is a fire.
- If you are a smoker, use the ash tray to extinguish the cigarettes. Never throw smoldering cigarette stubs in any waste paper basket. Do not smoke in the bed.
- Do not hang wet clothes on lamp shades and electrical heaters.
- Matchboxes and lighters should be kept outside the reach of children.
- If too many electrical appliances draw power from the same socket, fire can result from overheating. React promptly to the burning smell.
- Do not ignore fire alarms.

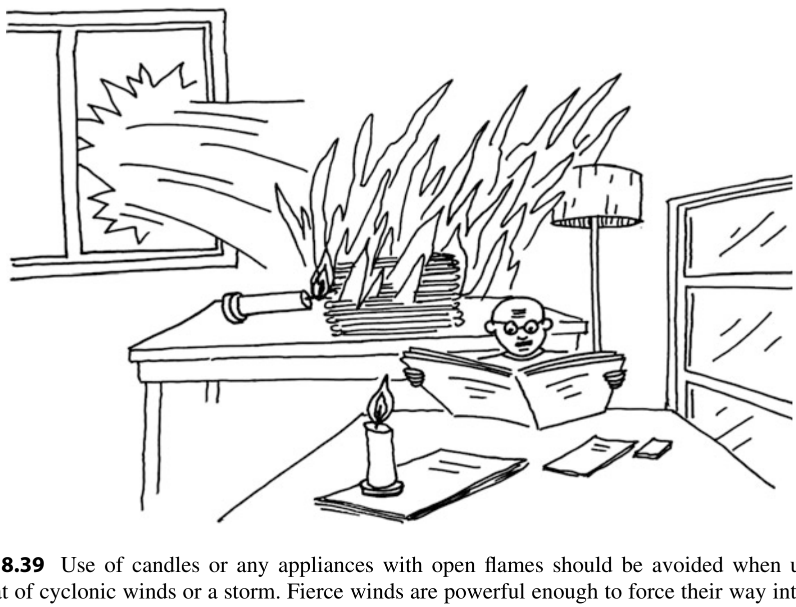


Fig. 8.39 Use of candles or any appliances with open flames should be avoided when under threat of cyclonic winds or a storm. Fierce winds are powerful enough to force their way into the house during a storm and knock down the candles to initiate a fire. It is preferable to use solar-operated or mechanical devices and to always keep the doors and windows shut

In Case of Fire

- If you hear a fire alarm, immediately escape by the nearest exit. Cover your nose and mouth with a wet cloth and protect your eyes, Fig. 8.40.
- Do not worry about your belongings and never use a lift.
- If you detect any fire or fire smoke, break the glass of the nearest fire alarm call point and call the nearest fire station.
- Use the nearest fire extinguisher or fire hose reel or sand buckets to put-out the fire. Do not wait to observe fire or smoke. Just escape and call for help, if and when needed.
- If the fire gets out of control, at once think of isolating the fire, for example, by shutting the rear door, and leave the building.
- If you get caught in smoke, take short breaths to prevent smoke getting into your lungs and crawl on the floor to escape the rising smoke. Remember that air at the floor level is relatively cleaner and less toxic.
- Do not jump out of the building. Rescue may be just a few minutes away, Fig. 8.41.
- Never return to a building on fire for any reason; not even for saving lives unless you are a trained fire fighter.

Fig. 8.40 When faced with highly toxic gases which are often released because of a fire, a volcanic eruption or an accident in a chemical plant, use of wet cloth to cover your nose and mouth, and tight glasses to protect your eyes. People can also be seen using masks

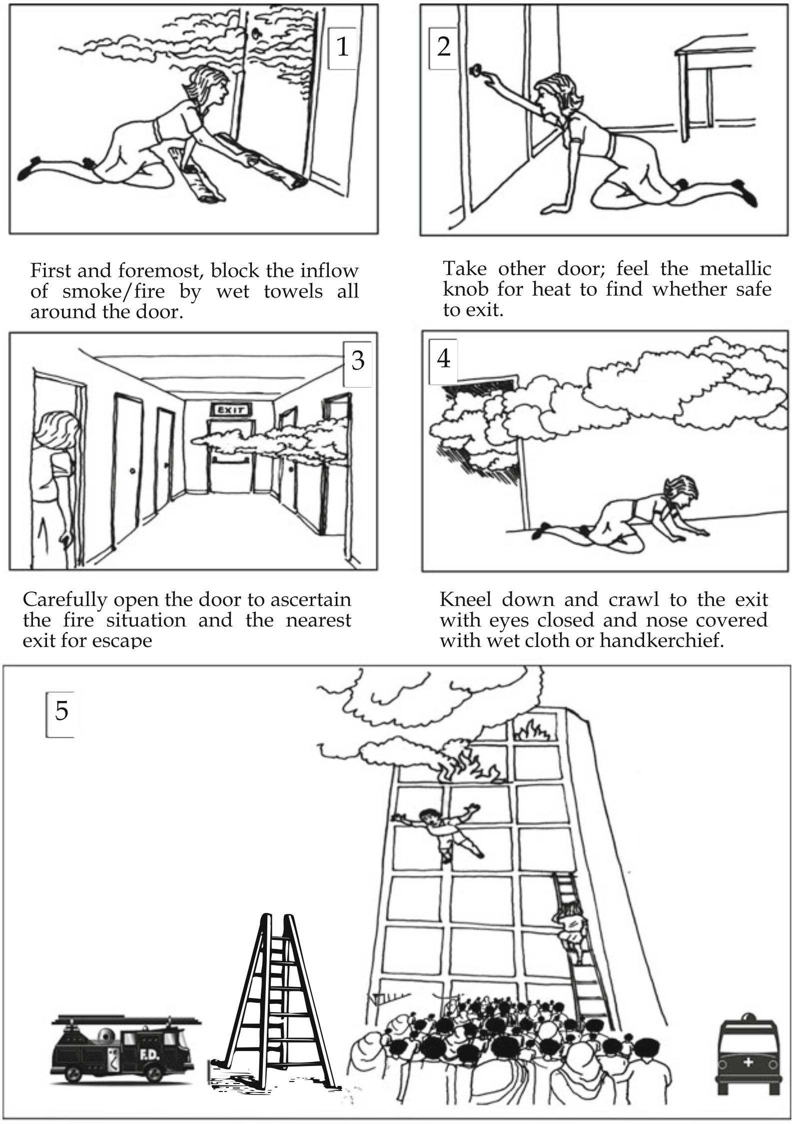
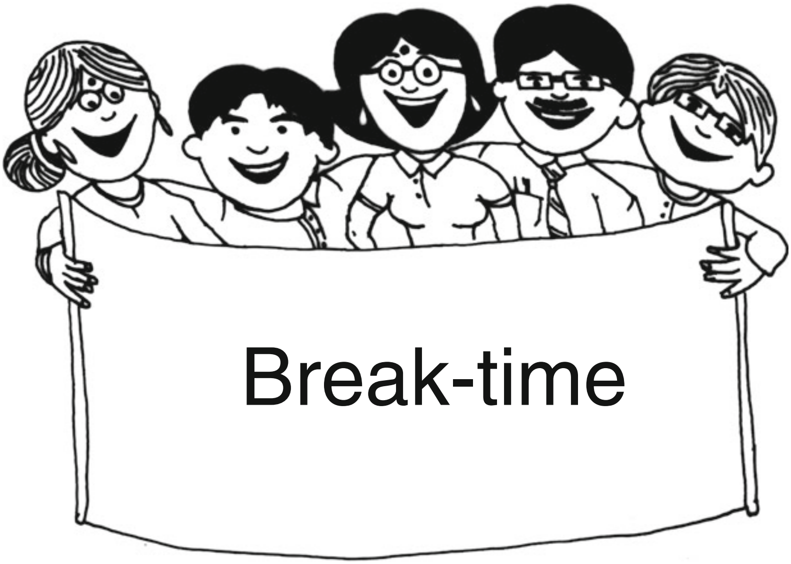


Fig. 8.41 *1* First and foremost block the inflow of smoke/fire by wet towels all around the door. *2* Take other door; feel the metallic knob for heat to find whether safe to exit. *3* Carefully open the door to ascertain the fire situation and the nearest exit for escape. *4* Kneel down and crawl to the exit with eyes closed and nose covered with wet cloth or handkerchief. *5* Upon reaching the exit point, look for help without getting panicky and never jump unless specifically advised by fire-rescue experts to do so

- In case of electrical fires, pull out the plugs or switch off the power. This may stop the fire immediately.
- Do not use water to extinguish fire due to an electrical short circuit. Instead use sand buckets to put off the fire.



Break-time question 18: Recall two or three catastrophic fire incidents in which by following simple rules of personal safety, people could have saved their lives?

Answer to Break-time question 18

The first incident narrated below is when a simple wet handkerchief covering the nose and mouth separated life from death.

On the fateful night of 2–3 December 1984 when world's one of the worst industrial disaster occurred at the Union Carbide Limited's pesticide plant in Bhopal, India, over half a million people were exposed to methyl isocyanate gas. When the gas leaked from the plant, the people in the neighborhood woke up in the middle of the night in the lap of panic and chaos. Burning of eyes, intense coughing, and inhalation of poisonous gases instantly killed over 2,000 people. Many lives would have been saved if the affected people were aware of the fact that by trying to run away, they became even more vulnerable to death by suffocation. Mere covering of the nose and mouth with wet cloth might have saved many lives. It is pity that medical men in the hospitals did not even know about the types of poisonous gases released and the related treatment. Timely detoxification of survivors by sodium thiosulphate could have saved further lives.

There have been many fatal fires which killed hundreds of people and in each case we often find examples of heroic escapes. Many of these became possible merely by following simple rules of safety.

People saved their lives by knowing the difference between the safest and the nearest exit. For those haunted by fire and smoke, the sole aim should be to rush to the safest exit door. While doing so, people with common sense avoid encounters with smoke and fire by merely kneeling down low and crawling in the passage or corridor. Those who lose lives are often those in panic who begin to crawl toward the nearest exit door without even covering nose, mouth, and eyes. Then, in the very same situation, there are some others, who keep their cool, quickly assess the ground situation, visually map the fire, its direction and its spread, cover their sensitive organs adequately, kneel down to the lowest possible position and smartly take the safest exit route, Fig. 8.42.

None of these guidelines are absolute and we must understand the basic grammar of safety, display presence of mind, and modulate our responses according to the situations we face. For instance, if it were to be thunder and lightning instead of fire, we would still kneel down to a low position but with the minimum possible contact with the ground, Fig. 8.43.

It is pity that many people, even when their clothes catch fire, run in panicky. By doing so, they only invite a bigger problem. Smart people, on the other hand, starve the fire of oxygen by rolling on the ground, Fig. 8.44.

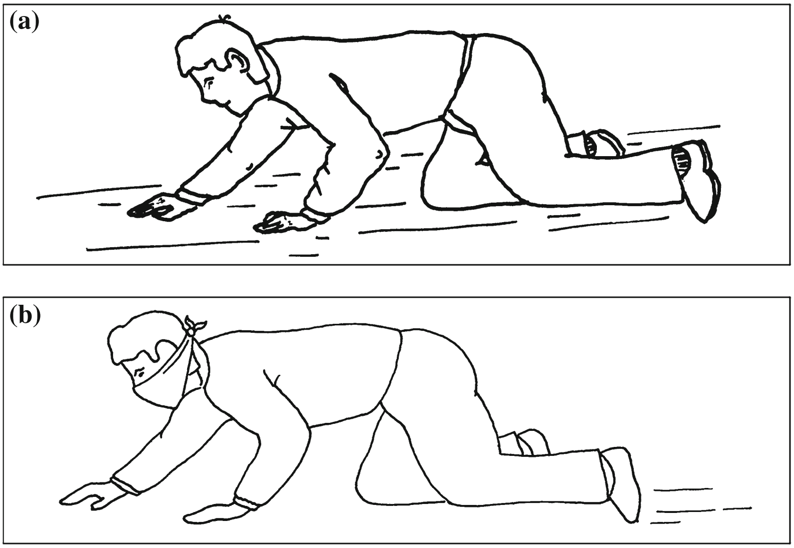


Fig. 8.42 **a** The kneel down position people normally take to crawl to escape from smoke and fire. By not covering eyes, nose, and mouth, they remain vulnerable to smoke and fire. **b** Since you are likely to encounter fire and smoke, always cover your nose and mouth as shown, and close your eyes

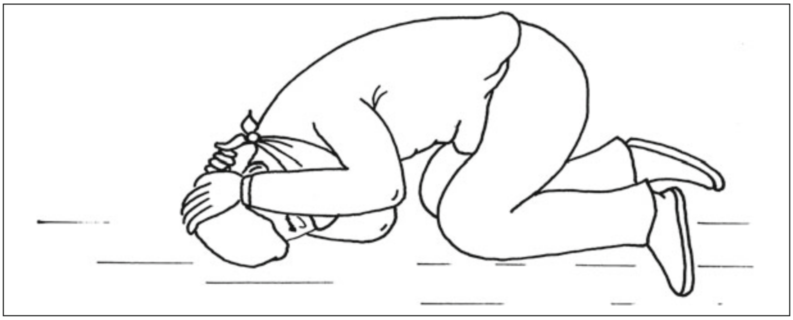


Fig. 8.43 Kneeling down in lightning is a different posture than kneeling down in fire. Lightning readily travels through wet ground which is why it is advisable to keep minimum contact with ground

The third example refers to a grave situation faced by people when they suddenly get buried under heaps of debris, for instance, after an earthquake or a landslide. Those who lose their cool invariably try to toss, turn, and struggle to come out as they shout for help. Both of these actions create undesirable vibrations because of which, the loose debris begin to compress. Consequently, the void spaces through which breathing was earlier possible may get blocked reducing the chance of survival. On the other hand, those who keep themself cool will

Fig. 8.44 It is never safe to run when clothes are on fire. In such a situation, roll on the ground as shown above to starve the fire of oxygen. Never run to escape because by doing so you will be stoking the fire rather than extinguishing it

Fig. 8.45 Those who get buried under a heap of debris ruin their chances of survival by to struggling to come out and by shouting. Little do they realize that they are able to breathe only because of the air pockets and voids around them and by creating vibrations they may block the passage of oxygen and get suffocated. Those who stay calm and refrain them from shouting and creating body movements, improve their chances of survival. The wise among them try to capture attention of the rescue team by tapping the closest solid wall or pipe conduit. The above figure shows how a victim attracted a rescue team by tapping a nearby pipeline

invariably take recourse to some other methods of attracting the attention of the rescue team. Instead of shouting and struggling which may prove fatal, they may, for example, tap a nearby wall or a conduit, Fig. 8.45.

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About the Author

Dr. R. K. Bhandari is a passionate champion of disaster education, and a noted geohazard expert, an unconventional teacher, a value-based practitioner, and above all a day dreamer of *disaster-free-world*. His motivation for writing this book on disaster education for students, teachers, and disaster managers came primarily from the writings of Aristotle who regarded education as *an ornament in prosperity and a refuge in adversity*. A speaking cartoon of Mahatma Gandhi drawn by Ranga inspired him to use the medium of cartoons as a powerful magnet to attract even those who hate reading.

Early scientific work of the author was on landslide disasters in the Indian Himalayas, mudslides of the Isle of Wight and the Isle of Sheppey in the United Kingdom, and on landslides in the Central Highlands of Sri Lanka. The great Malpa rock-avalanche-tragedy of 1998, the Orissa super-cyclone of 1999, the Gujarat earthquake of 2001, the Indian Ocean tsunami of 2004, and the Great Kedarnath tragedy of June 2013 are some of the recent disastrous events on which he has lectured and written extensively. His major exposure to human-induced disaster came with the terrorist bombing of the United Nations headquarters in Baghdad in August 2003, and the consequent evacuation of his team from Baghdad. As the director of the UN-HABITAT program in war-torn Iraq, at onetime his team was responsible for post-disaster housing of internally displaced people under very difficult ground conditions at a defining moment in Iraq's history.

The author is the recipient of numerous medals, awards, and honors including the prestigious 2012 Varnes Medal-the highest award of the International Consortium of Landslides; Distinguished Alumnus Award of the Indian Institute of Technology, Bombay; Overseas Fellowship of the Royal Commission of the U.K. for the Exhibition of 1851, Bhasin Foundation Award for Science and Technology; Jaikrishna Prize; Kuekalmann Award of Indian Geotechnical Society; Disaster Prevention Award of Indian Institute of Technology, Roorkee; and the Distinguished Engineer Award of the Institution of Engineers (India). He is a Ph.D. in Soil Mechanics from the Imperial College of Science and Technology, London; a Fellow of Institution of Civil Engineers (London); and the Chairman of the Forum on Engineering Intervention for Disaster Mitigation of the Indian National Academy of Engineering.

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Annexure 1

Annexure 1

Know about Some Major Disasters

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Some Major Disasters

Avalanches

- At about 09:30 h in January 1954, one of the worst snow avalanche in the Austrian history hit the village of Blons near Bludenz in the Austrian Alps. Of the village population of 365, about 57 people were killed and nearly half as many got injured.
- A formidable snow avalanche which destroyed villages of Chungar, Peru, and neighborhood on 19 March 1971 killed about 600 people, most of whom were women and children. This case record is a good example to demonstrate that sometimes even the trigger of a small earthquake is enough to create a devastating avalanche. The trigger of this avalanche came from a small earthquake in the Andes in Peru.
- A deadly avalanche hit the village of Galtur, a famous ski resort in Austria near Swiss border in the afternoon of 23 February 1999. Traveling at a speed of nearly 300 kph, it acquired such a force that it overturned vehicles and destroyed buildings enroute, burying nearly 57 people of which 31 were killed.
- In the wee hours of 1 March 2010, a deadly snow avalanche hit two trains at Wellington, near Stevens Pass in Cascade Mountains of Washington State of the USA. It consisted of a rapidly moving wall of snow nearly 5 m high. As a result, both the trains on the Spokane–Seattle route, got stuck in snow drifts, and were eventually thrown downhill into the Tye river valley killing 96 people, most of whom were asleep.

Blizzards

- The Blizzard which hit the north eastern United States during March 11–14, 1888 has earned the reputation of being Great, Iconic, and Legendary. On the 11 March, when the cold Arctic winds from Canada came logger heads with the Gulf winds from the southern parts, temperature nose-dived; rain became snow and the winds speeds soared to about 72 kph. Snow was seen everywhere by the morning of the 12 March with snow piling to the thickness of more than one meter in parts of New Jersey, New York, Massachusetts, and Connecticut. Snow drifts became as tall as the two storied buildings bringing the life to a grinding halt. There was a complete breakdown of transportation and communication system. More than 15,000 people got trapped in trains and elsewhere. People had to remain indoors for about one week, some of them even without food. Nearly 400 people were killed.
- The blizzard of May 10–11 on the Mount Everest has come to be known as one of the deadliest in the Himalayan history. It killed nine climbers and four others became victim of severe snow bite. A number of books have been written on this tragedy. The Google eBook: Into Thin Air by Jon Krakaeur, published in 1997 became the best seller.

Cyclones

- On September 8,1900, Galveston Island Hurricane of category 4 hit Texas killing thousands. Its fury was so great that the winds blew at 190 kph destroying buildings and the storm surges rose to unprecedented heights to submerge even the highest of the land areas. This deadly event will also be remembered with a deep sense of anguish that although the people were warned, they did not heed to the warning.
- It was the night of 15 November 2007 when a highly violent, category 4 tropical cyclone, Sidr, slammed the south and south western coastline of Bangladesh. The wind speeds reached 220–240 km/h; storm surges topped 5–6 m and about 3,000 people were killed. Compare this with the two earlier equally violent Bangladesh cyclones of 12–13 November 1970 and 29–30 April 1991. The former killed 500,000 people and the latter killed close to 140,000 people. The message is clear. Violence of a cyclone may be high but even then the vulnerability of the people could be drastically reduced through preparedness and timely human intervention. Thousands of lives were saved in the cyclone of 15 November 2007 because people were warned early and nearly 3.2 million people could be timely evacuated to the cyclone shelters.
- Hurricane Katrina struck the states of Louisiana, Mississippi, Alabama, and Florida of the USA during August 25 to September 2, 2005, killing between 1,500–2,000 people and inflicting losses to the tune of $75 billion. For the affected people, the calamities come in a row when they were hit by two other hurricanes Rita and Wilma shortly afterward. Flooding played havoc when the levees protecting New Orleans inundated the city.

Droughts

- It was the Great Indian drought of 1876–1878 in the southern Indian states from Poona to Bangalore that one of the worst famines occurred in the long history of famines in India killing nearly 5 million people. The drought which began with the failure of southwest monsoon rain got aggravated with the equally depressing northeast monsoon leading to a widespread crop failure. About the same period (1876–1879), China too suffered a deadly drought will took toll of about 9 million lives. The drought was so prolonged and severe that rivers became dry, crops were destroyed, and livestock perished.
- The drought of 1984–1985 in East Africa is regarded as one of the worst tragedies that affected over 13 million people. The crisis situation worsened to a new low when 500,000 Ethiopians already in the grip of the drought were joined by caseloads of over 100,000 refugees from neighboring Somalia, Sudan, and Eritrea. Deaths due to drought were both due to starvation and conflict. The experience has proved that starvation is easier to prevent than droughts, with efficient management of the buffer stock.

Earthquakes

- It was in the morning of January 23, 1556 that a massive earthquake (Magnitude 7.9) struck the Shaanxi province of China with its epicenter in Wei River Valley near the cities of Huaxian, Weinan, and Huayin. This earthquake affected as many as 97 counties of China killing about 830,000 people. The deaths occurred mainly because of the collapse of buildings in Huaxian and because of the collapse of caves due to liquefaction of loess cliffs which buried people.
- Lisbon the most beautiful city of Europe in the kingdom of Portugal was hit by a great earthquake with magnitude in the range 8.5–9.0 killing about 50,000 people in morning of November1, 1755 at 09:30 h. The epicenter of the earthquake being in the Atlantic Ocean, it created a deadly tsunami. It covered a distance of about 6,000 km in 10 hours' time. The earthquake chose to strike on All Saints Day killing the worshippers and knocking down even churches perhaps to tell us that earthquakes are not acts of God and the people were killed not by God but by the failure of public buildings, churches, and dwellings. The earthquake also triggered a fire which burned for as many as 6 days. On the positive side, this earthquake gave birth to scientific studies marking the beginning of modern seismology.
- The Great Assam earthquake (M = 8.0–8.1) occurred at about 05:15 h in the morning of 12 June 1897 sending shock waves from Burma (now Myanmar) to New Delhi. It killed 1,500 people and affected over 650,000 km^2 of area. It is considered to be largest intraplate earthquake which destroyed the northeastern State of Meghalaya causing widespread collapse of buildings, liquefaction failures, and flooding. The fault-movement was so violent that the northern edge of the Shillong Plateau rose by 10 m.
- The Great San Francisco magnitude 8.3 earthquake of 18 April 1906 shook the entire city for about 40–60 s. It had its epicenter near San Francisco bay and chose to strike at 05:12 h in the morning leaving no chance for people to escape. The earthquake was felt from southern Oregon to southern Los Angeles and central Nevada. The widespread damages included spread of fire, liquefaction failure of reclaimed ground in the San Francisco Bay, the toppling of tall chimneys, sinking of roads, collapse of buildings, failure of retaining walls, and rupture of gas pipelines. The reported death toll of 700 is considered a gross underestimate. The only positive gain of this devastating earthquake was the opportunity to add a few more bricks to the edifice of knowledge.
- The Great Kwanto Earthquake of 1 September 1923 struck the Kanto plain in the Sagami Bay of the Honshu island of Japan at about 11:58 h of the morning, which happened to be the lunch time and the first day for children at school after a long break. The tremors continued for more than 4 min knocking down the houses in Yokohama and Tokyo and triggering fire due to the toppling of stoves. Nearly 143,000 people were killed. Interestingly, the force generated by the earthquake was so great that in Kamakura, about 60 km away from the earthquake epicenter; it literally moved a huge statue of Lord Buddha weighing

about 93 tons by almost about 60 cm. A student might ask the question, was earthquake more powerful than God?

- The Great Alaska earthquake of 27 March 1964 was the second largest (M = 9.2) recorded in the history. It struck the Prince William Sound region of Alaska at 17:36 h local time for about 4 min with epicenter 120 km east of Anchorage. The shock waves were felt all over the planet Earth. Although the damages were spread over about 130,000 km^2 of area, the loss of life was limited to about 140 deaths, thanks to very low density of population. Besides causing damage to property, the earthquake resulted in a number of landslides including submarine failures. The tsunami caused by it also affected Hawaii and Japan.
- The Great Tangshan earthquake of 28 July 1976 (M = 8.0) Tangshan in China killed about 250,000 destroying the entire city of nearly 1.1 million population. About 160,000 people were injured. This earthquake is specifically discussed in this book.

Famines

- A gripping account of the Great famine of 1906 in Surat, India was provided by Lala Lajpat Rai, a noted Indian freedom fighter, in one of his articles. In his own words[1]: "A large number of them (people) seemed to be on the verge of death. We wanted to give help to select cases and we have given only a few doles. When we were observed doing so, a whole regiment of children and others rushed on us with cries of help. The volunteers threw some handfuls of coppers, and the scene that ensued was so pathetic and heart-rending that I had to ask him to desist from doing so… . It was in this camp that the idea seriously entered my head whether it would not be more humane to let these people die at once because a large number of them are sure to die in the end."
- The great Indian (Bengal) famine of 1943 was unquestionably one of the worst human tragedies of the colonial history of India in which the streets of Calcutta and rural Bengal were virtually littered with the devastated and the dead. It affected 20 million people of which more than 1 million died and thousands committed suicide. The story which began with food scarcity in slow motion climaxed when the Bengal typhoon of 16 October 1942 hit hard killing more than 40,000 people and robbing Bengal of its fertile soil cover and cattle population. The situation worsened as the supply of rice from Burma driedup because of the Japanese occupation of Burma and the added refugee population. Supplies of rice from Orissa and Bihar also dwindled out about the same time. What is worse, export of rice by the British Government from Bengal to Iran and Ceylon (Sri Lanka) continued. Greedy traders added fuel to the fire of demand.

[1] Reference: Lajpat Rai: Life and Work. Authored by Feroz Chand. Publications Division of the Ministry of Information and Broadcasting. Government of India published in September 1978. Pages 224–225.

- The Great Leap Forward Famine (1958–61) in China[2] is regarded as the worst ever human catastrophe that killed millions of people.[3] In China's quest to leap-frog into industrial economy, millions of farmers were forced to give-up agriculture to work for factories. Because of drought, sustained poor weather conditions and governance deficit, the grain output declined by 15 % in 1959 and consequently the food supply dropped substantially. Food distribution was so faulty that in Xinyang, people reportedly starved outside a warehouse.

Fires

- The Great Fire of Meireki in Japan, also known as Furisode Fire of 18–20 January 1657,[4] destroyed nearly two-thirds of the capital city of Edo (now city of Tokyo). The fire lasted for 3 days in which between 100,000–200,000 people lost their lives. If one were to analyze what led to the huge spread of fire, a number of factors will surface. Use of wood and paper in construction was one reason. The drought prevailing at that time made buildings bone-dry and more fire prone. Northwesterly winds helped it to fan out the fire which first broke in Hongo district at the center of Edo. Winds quickly attained hurricane intensity to fan the fire out-of-control. Narrow spaces between buildings served as ducts to further stoke the fire. Even after fire died out on the third day, smoke continued to paralyze life for many more days.
- The night of 8 October 1871 will always be remembered for two separate fire disasters—the Great Peshtigo fire disaster of the northern Wisconsin and the Great Chicago fire disaster. The former killed between 1,200 and 2,400 people and the death toll in the second was about 250. Close to 2 billion trees got burnt by the former and about $200 million of damage was caused by the later.
- The Great Yellowstone National Park Fire of May to October 1988 in the State of Idaho affected nearly 1.2 million acre of area and forests.

Floods

- The North Sea flood from 31 January to 1 February 1953 will be remembered as the flood which inundated the coast-lines of eastern England, and the Netherlands, besides flooding Belgium, Denmark, and France. The floods resulted from a deadly combination of high spring tide and a severe wind storm raising mean sea level locally by 5 m. The storm tide triggered tidal surge which destroyed the sea defenses. Many trawlers sank, the ferry Princess Victoria was lost, and about 1,853 people died in the Netherlands alone.

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[2] For further reading: Xin Meng, Nancy Qian and Pierre Yared (2011); The Institutional Causes of China's Great Famine.

[3] The estimates of dead vary in the range 15–30 million.

[4] Some historians believe that the Great Fire of Meireki broke on 2 March 1657.

- The Great Mississippi river flood of 1993 surpassed the earlier floods of 1927 and 1951 in terms of the post disaster impact. It submerged 78,000 km^2 of area including 75 townships, damaged crops, overtopped hundreds of levees, destroyed over 10,000 houses, rendered thousands homeless, and brought the entire river navigation to a stand still. About 50 people were killed and the total estimated damages touched $50 billion mark.

  It all started with heavy snowfall of 1992–1993 winter followed with heavy rainfall. Rainfall resulted in rapid water saturation of ground, increase of overland flow, overloading of water streams, and overflowing of river channels. Floods of Minnesota and Wisconsin eventually reached Mississippi and Missouri rivers.

Landslides

- Located on deltaic alluvial deposits, about 2 km away from the coast, between the mouths of the rivers Cernites and Selinus in Greece, the town of Helice was swept away into the sea by a flowslide resulting from an earthquake shock. It is perhaps the earliest reported case of a landslide resulting from soil liquefaction induced by an earthquake.[5]
- The 1963 Vajont dam landslide disaster of Italy is one of the most studied and spectacular landslide case records of recent times. Vajont dam 265 m high was located in the northern Italian Alps and was constructed on a tributary of river Piave during 1957–1960. On the 9 October 1963 at about 22:39 h, a spectacular landslide occurred killing as many as 1925 people. The landslide carried about 275 million m^3 of rock into the Vajont reservoir with water level two-thirds full. The landslide mass swiftly moved downslope at speeds estimated between 90 and 250 km/h.[6] The huge water wave so created overtopped the dam by as much as 70 m. Consequently, the slide debris rode the valley sides as high as 260 m and traveled about 2 km down the valley. The town of Longarone and villages of Pirago, Villanova, Rivalta, and Fae were devastated.
- Watawala earthslide in Sri Lanka was initiated during laying of the railway track at Watawala on 19 August 1886. At that time it was called "the most formidable landslip which befell the Ceylon Railway at the Black Water cutting between Galboda and Watawala. At this location, a down train from Nanuoya was about to pass the spot when watchers scented trouble and stopped the train. Within a short time, at about 06:00 pm, the whole of the south side of the hill moved forward from the fountain level burying the line under a mass of debris over 70 feet high for a distance of about 162 yards. The quantity of debris is estimated at 150,000 cubic yards of which at least four-fifth was rock. The attempts to allow trains to pass were frustrated by the second slip which took

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[5] *Source* Marinatos, S. N. (1960): "Helice Submerged Town of Classical Greece."

[6] Chapter V Damage and the built Environment in the Human Impact and Response.

place on the night of 10 November 1886 blocking the cutting again."[7] The major earth slide events at this location repeated in June 1981, May 1984, June 1992 and October 1993. On 3 June 1992, a major railway accident got averted. It was at that time that the earthslide was thoroughly investigated and successfully fixed. Visitors will see the slopes with dense vegetation without any trace of the earthslide.

- In the year 1903 on the 29 April at about 4:10 h local time, Frank Rockslide[8] of the Canadian Rockies drove off from the Crow's-nest Pass of the Turtle Mountain. This was because a huge mass of overhanging lime stone broke into myriad of pieces as it fell down from great heights and then ran across the narrow valley. This was akin to what happened at the Malpa rock avalanche tragedy of Uttarakhand in India. The residents of the eastern parts of Crow's-nest pass thought it was perhaps the end of the world. They hardly had any time before getting overwhelmed by millions of tons of rock that hurtled down the slopes. The message from a telegraph staff read: "Earthquake almost destroyed town. Hundreds killed. We are safe." All was over in 100 s killing atleast 66 people.

  The story of the Frank rockslide as told by some miners who could come out of heaps of debris safe, in the words of Yackulic, "remains an epic." As the northeastern parts of mountain broke plunging into the valley, the racing rock mass went well past the Crow's-nest river, crew of the passing train could hear the thunderous noise of moving rocks. It took time to convince survivors that earthquake had not occurred.

  There were many miraculous escapes. The most stunning story is of a baby girl by the name Marion Leitch who had an unbelievable escape. Her family home was crushed by the moving mass of the rockslide but she somehow landed on a boulder which crashed against another house. Despite all this, she was found sitting safe in one piece on a bunch of straw carried by the boulder.

Lightning

- On 18 August 1769, lightning struck an Italian church in Brescia and exploded 1,000 tons of gunpowder which destroyed large parts of the city and killed 3,000 people.
- On 3 April 1856, a church in the Island of Rhodes was struck by lightning. Nearly 4,000 people were killed because gunpowder stored in the church, got ignited.
- On 10 July 1926, lightning struck an ammunition dump in New Jersey killing 21 people.

[7] Perera GF (1925): The Ceylon Railway—The story of its inception and progess. Published by The Ceylon Observer, London.

[8] George A Yackulic (1952): The Slide that shook the West. A Chapter in the book: In the Face of Disaster edited by Michel Benedict and published by the Penguin Group in 2000. ISBN0-670-88883-4.

- On 8 December 1963, a fireball explosion due to lightning lit up the sky and it took quite a while to figure out that the lightning had struck Pan American Boeing 707 over Elkton in Maryland killing 73 passengers and 8 members of crew. The plane, had started at 16:10 h from Puerto Rico to Philadelphia via Baltimore. Those who got down at Baltimore were lucky because it was only after the plane left Baltimore at 20:25 h that the accident occurred. It was for the first time that aviation industry came to realize the threat of lightning to aircrafts flying in bad weather.
- On 23 December 1975, a lightning struck on the eastern highland village of Chinamasa in Zimbabwe killing 21 people. It turned out to be the lightning strike which placed Zimbabwe on the world map in terms of its vulnerability to lightning.

Plague

- Between 430 BC to 426 BCE, Athens in Greece suffered from outbreak of a plague during the Peloponnesian war against Sparata. The plague was attributed to overcrowding, poor water supply, poor sewerage, and high humidity. It killed about 30,000 people.
- Between 542 BCE to 543 BCE, plague of Justinian was the first pandemic of bubonic plague that devastated Africa, Asia Minor, and Europe. In the first year of Plague itself, nearly 300,000 people were killed in Constantinople.
- Between the 5-year period 1347 to 1352 AD, a devastating bubonic plague claimed about 20 million lives in the Europe. The name *bubonic* came from the lymph glands called *buboes*. It is reported by many that *fleas* transmitted the disease to the people who developed fever, pain, and red-spots on their skin due to the swelling of buboes. The red-spots on the skin turned black giving people the so called *black-death* and the plague itself its name-*black plague*. It reportedly spread from Asia to Europe along the trade routes causing total breakdown of social system and wide spread chaos. The speed with which the disease took toll of lives is best described by quoting Boccaccio, an Italian writer, who said that "*victims often ate lunch with the friends and dinner with their ancestors in paradise.*"
- The Great Plague of 1665–1666 in Great Britain,[9] the worst ever outbreak of plague in the human history, hit London so hard that it lost 15 % of its population. Nearly 68,596 deaths were recorded in London alone, and with the spread of plague to the southeast England, the total number probably approached 100,000. It all began in the spring of 1665 worsening steeply in the hot summer of April to September. The situation became so alarming that just within a period of one week, London lost 7,156 people. This figure of deaths was in a staggering contrast with the death toll of 725 people in the last week of June. This happened as the plague initially caused by rats spread through fleas hobnobbing the garbage dumps and the waste piles.

[9] The Great Plague-The diary of Alice Payton, London, 1665–1666 (My Story).

The impact of the plague was so profound that the British Parliament could not even hold its meetings in London and its activities had to be shifted to Oxford. Charles II too, sensing trouble, shifted first to Hampton Court and then to Oxford in July 1665 leaving the Lord Mayor and his Councilors to *guard the forte*. All movement of goods and trade were suspended, the movement of affected people got curbed, and for sanitary disposal, special burial pits had to be created. It is extraordinary that the great 1665 fire of London which was a disaster in itself came as a big relief for the victims of the plague which would have otherwise been even more severe and prolonged.

Tsunami

- The tsunami of 15 June 1896 was triggered at 19:32 h local time by Meiji-Sanriku earthquake of magnitude 8.5 off the coast of Sanriku in the Honshu island of Japan. It destroyed 9,000 houses, more than 250 km of the coastline and killed nearly 22,000 people. It is a point to note that fishermen who were out fishing 30 km away from the coast did not even know that tsunami waves were passing beneath their boats because the wave height was not even half a meter. The very same tsunami waves attained a height of 22 m when they struck the coast. This tsunami was also observed across Pacific with about 3 m high waves in California. The only silver lining was that this tsunami disaster gave a big impetus to tsunami research.
- The tsunami of 1 April 1946 was triggered in the early hours of the morning by an earthquake of magnitude 7.4 off the coast of Aleutian Islands in Alaska. In less than one hour of the earthquake, the first tsunami wave train reached Scotch Cap destroying US Coast Guard light house, killing five people. In about 5 h, the tsunami waves reached Hawaiian Islands, attained a height of about 10 m killing 159 people. The tsunami had a little effect on the Alaskan main land for which Aleutian Islands acted as a protection shield.
- The Indian Ocean tsunami of December 2004, triggered by an underwater earthquake of magnitude 9.0–9.2, is considered to be one of the worst natural disasters of the twenty-first century affecting more than one dozen countries. According to one estimate, it released more energy than the cumulative energy released by all earthquakes in the preceding period of a quarter century. It killed nearly 300,000 people.

Tornadoes

- The Great tornado of 18 March 1925 affected the states of Mississippi, Illinois, and Indiana in the USA destroying the towns, killing 689 people and injuring 2,000 others, besides inflicting a damage amounting to \$16–18 million. This twister of F5 category will be remembered for its longest (350 km) continuous track on the southern Missouri-southern Illinois—southwestern Indiana route, with wind speeds exceeding 100 km/h and duration exceeding 3 h.

- A devastating tornado struck the downtown Lubbock in Texas on 11 May 1970 killing 26 people and injuring more than 1,500. This tornado will continue to be remembered for two things. First, it motivated Theodore Fujita to develop what is now the famous Fujita-Tornado-rating scale and second, it inspired structural engineers to evolve improved earthquake-safe designs by using the study of the twisted frame of a 20 storied building.
- A deadly tornado struck parts of San Justo in Argentina killing 54 people, injuring 350 and destroying about 500 homes. The tornado reportedly cut a 300 m swath through the town of San Justo, 480 km northwest of Buenos Aires with force so great that vehicles got lifted and, according to one description, trees flew like matchsticks.
- A deadly tornado struck Belynitsky, Ivanovo, and Balino in Russia on 9 June 1984, killing about 95 people and injuring another 130. It flattened homes and damaged structures made of reinforced cement concrete along its 800 m wide and 130 km long track.
- A deadly tornado struck Bangladesh north of Dhaka on 26 April 1989 killing 1,300 people and injuring more than 12,000, besides making 80,000 people homeless. It cut a 600 m swath playing havoc along the Daulatpur–Saturia route inflicting damages in the towns of Saturia and Manikganj.

Volcanoes

- If one wants to see Europe's tallest, active stratovolcano (c.3350 m high with 38×47 km elliptical base), one should think of Mount Etna on the east coast of Cecily, close to Messina and Catania. One of most notable of the events was the eruption of 11 March 1669 which killed nearly 20,000 people while destroying the town of Catania in Italy. Since then this volcano has been erupting time and again but it is not considered to be of any immediate threat. The airport of Catania is functional. It is beautiful to watch the eruption when the summit and flanks erupt simultaneously.
- One of the largest volcanic eruptions of the past few centuries has been from Tambora, east of Java in Indonesia on 5 April 1815. It is remembered for its roaring sound heard hundreds of kilometers away and for the dramatic change of weather pattern in the region for a period of more than 2 years. Its ejecta-volume is estimated close to 160 km^3.
- The eruption of Krakatau volcano situated in the Sunda Straight between the Pacific Ocean islands of Java and Sumatra in the Dutch East Indies on 26 August 1883 was so violent that its sound was heard hundreds of kilometers away, its pyroclastic flows killed 36,417 people and thousands died of the volcano-induced tsunami. The skies cast in volcanic dust resulted in dramatic drop of temperatures and the ensuing forced volcanic winter. People as far as Great Britain and the USA experienced spectacular red sunsets because of the cover of volcanic dust. The volcano is active in that it last erupted in 2012.

- Eruption of Mount Pelee of 8 May 1902 in the Caribbean created spectacular pyroclastic flows which devastated the city of St. Pierre, killing its 28,600 habitants, sparing two eyewitnesses. Increase in volcanic activity seen in January 1902 steadily grew to trigger volcanic explosion on 23 April 1902. On the 5 May, a torrent of scalding water generated lahars that traveled at a speed of about 100 km/h burying everything enroute. The discharge of lahars into the sea triggered a tsunami which in turn flooded low-lying areas along the water-front of St Pierre.
- Mount St. Helens in the State of Washington erupted on 18 May 1980 to produce a northwardly directed blast generating a spate of pyroclastic flows traveling nearly 18 km in less than 1 min. It killed 57 people. The volcano exploded sideways and not upward as we normally expect volcanoes to do. The eruption created a 5 km long fracture, and toppled trees up to about 30 km distance. Nearly 1.6 billion board feet of commercial timber and fisheries in the area were badly affected.

Annexure 2

Annexure 2

References for Popular and Advanced Reading

The idea leading to the development of the above set of the two cartoons came from the original masterpiece published by the UNICEF, although in a somewhat different context. The permission of the UNICEF for use of their mother poster cartoon is gratefully acknowledged.

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Most grateful if you email your frank views. A few lines of your views and guidance posted at rajmee@yahoo.com will go a long way in improving the future editions of the book, strengthen acknowledgments and better serve the cause it represents. The author is already grateful to those who have expressed themselves as can be seen in the succeeding pages.

The above cartoon is inspired by the original cartoon from Priya Raj captioned under the pyramid published in 1997. www.priyaraj.com

Some Reflections on the Book

"The book *Disaster Education and Management—a joy ride for students, teachers and parents* provides a wonderful, well-illustrated framework that might be able to alert in cooperation with international partners many schools/ universities in many countries in order to 'promote' the holistic understanding of our Planet and the 'System Earth' with its risks. In order to close significant knowledge gaps in Earth sciences (and disaster risk reduction) and to improve teachers' capacity in teaching and students' geo-literacy to this end, we believe that the book of R. K. Bhandari can make a very significant difference in reaching out to the largest number of students, teachers and parents in the shortest time".

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Universidade Federal Do Parana, Brasil,
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"I'm sure that your book for will be strongly in-demand not only in India, but also world-wide, for which it should be translated local languages. It is extremely important to educate common people about natural hazards, especially those who are young, since it will facilitate societal protection in future. I'm ready to help with its translation in Russian and will investigate the possibility of its publishing in Russia."

Dr. Alexander Strom
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Former Director, IIT Roorkee and Vice Chair, AICTE

"Dr. R. K. Bhandari had pioneered the idea of developing a "National Natural Disaster knowledge Network", which the High Powered Committee on disaster management recommended for implementation to the Government of India in 2001. He has now extended the idea on to the world of students, teachers and disaster managers. His book "***Disaster Education and Management*** is a scintillating presentation of the basics of disaster risk reduction and management in addition to being a hilarious storehouse of useful knowledge to arouse the curiosity of students and teachers to further delve into the mysteries of the subject . I am sure Dr. Bhandari's labour in writing this book is bound to bear rich fruits in future. This book is a "must" for every trainer, rescue and relief worker and disaster professional to carry in his or her rucksack when stirring out to do their bit, and when not facing a disaster, they could go to every educational institute in the neighbourhood to tell students in an entirely joyful manner, about the book and train them how to do all that is needed to be done when facing a crisis".

J. C. Pant, IAS
Formerly, Secretary to Government of India and
Chairman of the High Powered Committee on Disaster Management

"I took joyride of some of the swings of your wonderful amusement park and enjoyed it thoroughly. I am sure this would be your unique contribution to disaster management education and would be recommended for students and teachers across countries and continents."

P. G. Dhar Chakrabarti IAS
Secretary, National Disaster Management Authority
Additional Secretary and Adviser
Inter-State Council Secretariat
Ministry of Home Affairs, Government of India

"Books which provide a synthesis of available concepts and facts are urgently required and this book fills one of the gaps in the materials available for educating the citizens and especially students about the state of our planet. The author has successfully minimized the technical jargon and facilitated accessibility and reader friendliness with good illustrations and cartoons. The vast range of Dr. Bhandari's knowledge and experience has ensured the inclusiveness of the contents and the illustrator has successfully reinforced the concepts and principles outlined throughout the book."

Professor Robin N. Chowdhury
Emeritus Professor, Wollongong University, Australia, and
The author of Geotechnical Slope Analysis, published by CRC Press.

"The book is truly a joyride, as it is magnetic in its presentation and comprehensive in its content not only for students, teachers and parents for whom it is primarily intended but also for a wide sweep of readership. Coming as it does from the rich first-hand experience of the author, it will certainly help in spreading disaster education and in bringing about the behavioural change we need for developing disaster resilient communities."

N. M. S. I. Arambepola
Executive Director a.i.
Asian Disaster Preparedness Center (ADPC), Thailand.

My compliments to Dr. Bhandari for the excellent effort in writing this book, which is very much needed in the area of disaster management. The book is unique in its style and architecture, and rich in its contents presented in a manner that even a common man can enjoy reading this book and get the basics of disaster risk reduction. The author has a vast experience of working in this area and that lends weight to the book.

Professor Vinod Sharma
Professor of Disaster Management
Indian Institute of Public Administration and Vice Chairman,
Sikkim Disaster Management Authority

The book *Disaster Education- A Joy Ride* is doubtless a masterpiece in Disaster Management education, research, and community upbringing. In the wake of global scenario of multiple threats to the very survival of mankind, the book has coasted home with an amazing treatment of the diverse aspects of human safety for sustainable upbringing. It would doubtless inspire a wide sweep of readership and help them raise their life skills for survival through peaceful co-existence with Nature. In the limitless domain of natural and man-made hazardous events, the author has not only been successful in showing masterly 'brush strokes' of his insights into diverse aspects of disaster education for all but has put in our hands a knowledge product which is definitely a must read for everyone.

Professor Chandan Ghosh
Professor, National Institute of Disaster Management

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