Understanding the Extreme Weather Events - Prof R R Kelkar

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Introduction

By definition, an extreme weather event is one which does not commonly occur at a given place and in a given season, and it is 'extreme' only in a relative sense. A temperature of 45 ºC on a summer afternoon in Jaisalmer would not be categorized as an extreme event, but it would certainly be regarded as one if Shimla recorded that temperature. When long-period climate normals are computed, extreme values get averaged out, losing the attention they deserve. It is only when an extreme event assumes the nature of a disaster, with heavy loss of life and property, that it becomes a matter of importance, examination, discussion and of course, controversy. Whatever the nature of the disaster, the following questions are commonly asked:

- Can the natural phenomenon be scientifically explained?
- Could it have been predicted?
- Could the disaster have been averted?
- Was the response adequate?
- Who or what was responsible for the loss of life and destruction?
- How can a similar tragedy be avoided in future?

The answers to some of these questions can be found in the way we live. Human beings generally adapt themselves to their surroundings. They tune their lives to the *mean* values of rainfall, temperature, river levels or ground water in their vicinity. They do not live in a constant fear of the unknown or highly improbable events. Imagine how miserable life would be, if one were to think all the time of dying, which, incidentally, is an event of the highest certainty! The other human trait is to encroach upon the surroundings, exploit natural resources, cut corners, build new pathways, make life easier and more convenient. Actually all living creatures exploit nature in their own ways, but human interference with the environment is unmatched in both extent and ingenuity. Nature tolerates it, but only up to a certain point. Once that threshold is crossed, both natural and human systems cannot take it any more, and we are into what is termed as a disaster situation.

The Nature of Monsoon Rains

We are indeed fortunate that while the impacts of global warming and climate change are being increasingly felt all around us, the Indian southwest monsoon is one phenomenon that stands out for its annual regularity. It is often said that life in India revolves around the monsoons. The monsoon brings prosperity, music, dance and romance. But like many other things in life, the monsoon too carries a price tag: 'variability'. While the monsoon comes with a reassuring regularity, it exhibits a wide range of variability on the spatial, temporal, intra-seasonal, inter-annual and decadal scale. This makes all the difference between floods and droughts, between Cherrapunji and Jaisalmer, between Mumbai and Ahmednagar. When the monsoon rains are timely and equitable, we do not bother, but when they are not, reality dawns once again. The monsoon has always had its vagaries and it is going to show them in future too.

The Western Ghats run parallel to the west coast about 50 km inland at an average height of 1.2 km. The strong winds of the southwest monsoon, carrying the moisture-laden clouds from the Arabian Sea, get pushed up on encountering the Ghats. When the clouds reach a height where they can no longer hold the moisture, they precipitate heavily over the windward coastal areas, while the leeside peninsular regions go dry.

The normal annual rainfall of the meteorological sub-division of Konkan and Goa is 298 cm, more than the normal annual rainfall of 279 cm over the Assam and Meghalaya sub-division which includes Cherrapunji, and a little less than the normal annual rainfall of 306 cm over the Andaman and Nicobar Islands. The normal annual rainfall of the Madhya Maharashtra sub-division is just 85 cm, which is only a little better than that of 68 cm over East Rajasthan (IMD, 2005a)

On the time scale of a day, there are many past instances of Indian stations having recorded as much as half of their annual rainfall, and some times even more than their annual rainfall, in one single day (Dhar et al, 1981). Rainfall of 50 cm or more in a 24-hour period is not an uncommon phenomenon at all (Rakhecha et al, 1980).

Mumbai Rains of 26 July 2005

The observatory at Santa Cruz in north Mumbai recorded a rainfall of 94.4 cm during the 24 hours ending at 8:30 am on 27 July 2005, while the Colaba observatory in Mumbai's southern tip recorded barely 7.3 cm in the same period. Rainfall over Vihar lake was 105 cm, even higher than Santa Cruz. The previous record of heaviest 24-hour rainfall over Mumbai was 58 cm for Santa Cruz and 37 cm for Colaba on 5 July 1974 (IMD, 2005b). Comparatively speaking, only Santa Cruz broke the previous record. For Colaba, the rainfall was in no way unusual.

Heavy rainfall (more than 20 cm) is quite common for Mumbai during the onset phase of the monsoon. It is caused by a convergence of the dry winds blowing at that time from the north with the advancing moist southwesterly winds of the monsoon, coupled with the development of an onset vortex either over the Arabian Sea or the Bay of Bengal.

However, after the monsoon has set in and goes into its active phase, the synoptic situation is conducive to the occurrence of very heavy rains over Mumbai when it has the following features collectively: (1) development of a low pressure area over the northwest Bay of Bengal, (2) intensification of the monsoon trough and development of embedded convective vortices over central India, (3) strengthening of the Arabian Sea current of the monsoon, and (4) superpositioning of a meso-scale off-shore vortex over northeast Arabian Sea and its northward movement. All these conditions were met on 26 July 2005 (Shyamala, 2005). The Mumbai downpour was the result of a combination of synoptic scale weather systems which have a span of 1000-2000 km, with meso-scale systems which are localized and extend over 20-30 km only.

Mumbai Flooding

An analysis of the probability of such extreme events and their expected return period based on historical data going back to 1886 for Colaba and 1957 for Santa Cruz reveals that in any year, the probability of 24-hr rainfall exceeding 20 cm is 50% for Santa Cruz and 33% for Colaba. The return period for a 20 cm rainfall over Mumbai is 2 to 3 years (Shyamala, 2005). [*Return period, see box in the article by A C Tyagi. - Ed.*]

On 5 July 1974, Mumbai had received 58 cm in a single monsoon day and the city had taken it in its stride. Just five years ago, on 13 July 2000, Mumbai had recorded exceptionally heavy rains: Vasai 49, Thane 45, Santa Cruz 37 and Colaba 25 cm.

This makes it clear that it was not the rainfall, but the inundation, that was truly unprecedented. Never before perhaps had the metropolis experienced anything like it. Suburban trains normally running at intervals of 3 minutes, came to a grinding halt and 150,000 commuters including schoolchildren got instantly stranded at railway stations. Buses were unable to ply and the roads were bursting to capacity with stagnant northbound traffic. Land lines, mobile phone services and power supply went dead in many areas. Highways connecting the city got blocked and the airport had to be closed. The island city was really marooned.

Had Mumbai received the rainfall of 94.4 cm in a day a century ago, the severity of problems would surely have been much less. The population of Greater Bombay, now called Brihan Mumbai, was less than a million at the beginning of the last century. The mid-century figure was around 3 million. By 2001, the population had grown to almost 12 million. The city has risen vertically, open spaces have dwindled, the arterial roads cannot be widened any further, smaller roads have become car parks, and the drainage systems cannot keep pace with the ever-increasing needs of the metropolis. Many people are literally living on the edge, in areas that are known to be prone to landslides.

Many different reasons have been ascribed to the Mumbai flooding of 26 July 2005. The two main causes cited are: (1) the uncontrolled urbanisation of north Mumbai and the destruction of mangroves, and (2) the inadequacy of the existing drainage system. Some of the arguments, and opinions expressed in the media, are qualitative in nature and based on what has been seen to happen. They may even be valid, but they need a critical and objective examination by experts before firm conclusions can be drawn. It is evident that in the process of housing construction and setting up of industries, the waterways that allow the accumulated rain water to drain out have been drastically reduced. Large slum colonies have encroached upon the storm water drains and the Mithi river, which is Mumbai's main river.

What is, however, debatable is the destruction of mangroves being made out as one of the factors responsible for flooding. There is no doubt that mangroves serve as a vital link in the ecological chain, acting as a buffer between land and ocean, and that destruction of mangroves will disturb the ecological balance. What needs to be considered in detail is the question whether mangroves, while protecting the coastal belts from the impact of waves, could as well impede the outflow of water from the land.

Forecasting of Urban Flooding

With rivers of central and peninsular regions of the country, flooding is an annual feature, caused by heavy monsoon rainfall over the catchment areas. Flooding in the Himalayan rivers is caused by heavy precipitation in the upper catchments and is aggravated by factors such as rivers changing their course, increase in the silt load, construction of embankments, etc. There is a well-organised system in this country for forecasting of river floods, which is run by the Central Water Commission with the active involvement of the Flood Meteorological Offices of the India Meteorological Department.

However, the type of flooding that occurred in Mumbai on 26 July is a very different matter. In fact, here, the term “flooding” is a misnomer, as it is not the result of water spilling over from a flooded river, but an “inundation” caused by accumulation of heavy local rainfall. In technical parlance, it is “drainage congestion” or the inability of the drainage process to match the rainfall rate.

Providing protection from drainage congestion is the responsibility of civic bodies or local authorities. Besides the characteristics of the rain storm, many other factors like proximity to rivers and ocean, local topography, traffic patterns, drainage design, housing, population density, all influence the severity of drainage congestion. A vital but tricky consideration in the design of drainage systems is the return period of the “most extreme” rainfall events. Usually an optimum balance has to be struck between over-estimating and under-estimating the risks involved and a major deciding factor is the cost. Population growth and urban development over say the next 100 years are also not easy to visualize and the choice of future projections will have its own impact on the design and cost.

River floods can be predicted because there is considerable time lag between the occurrence of heavy rainfall in the upper catchment and the consequent build-up of the flood flow in the river, and its travel to a downstream area. Such a lead time is not available in case of drainage congestion caused by local rainfall. Also, the propagation of a flood wave in a river channel is easier to compute. Mathematical or physical modelling of city drainage is, from a hydraulics point of view, a far more complex problem. Also required is a parallel system for *quantitative* prediction of the rainfall amount and rate on a scale that will match the scale of the hydraulic model. As of today, the state of art in these areas is rather primitive.

Disasters and Development

Two thousand years ago, a great Teacher narrated a parable which made a comparison between wise and foolish builders. The wise person built his house upon a rock while the foolish one built his house on sand. Then the rains came down and the floods went up. The house on the rock firmly withstood the torrents, while the house on the sand came crashing down.

In today's world, there can be no argument against development. No one can be denied the right to a better living. But urban growth has to be controlled and planned on the strong foundations of wisdom, foresight and discipline. Otherwise more disasters may be just waiting to happen.

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