Chapter 6
Where Are We?

Abstract Since the installation of the World Wide Standard Seismograph Network (WWSSN) and formulation of the 'Plate Tectonics Hypothesis' in the 1960s, there has been phenomenal progress in seismology. In relation to other science disciplines, the science of earthquakes and tsunamis is relatively young. Nevertheless, with the installation of several tsunami warning systems and expansion of seismological networks, our understanding of tsunami generation and advisories provided globally is significantly better now and improving.

A lot has happened since the occurrence of the 1755 Lisbon tsunami. At that time the debate was on whether an earthquake and a tsunami were due to the wrath of God or whether they were natural phenomena. The questionnaire that was sent to collect information regarding the felt and related observations of the public are relevant even today. It is said that the occurrence of the 1755 Lisbon earthquake and the investigations that followed laid the foundation of seismology. The Lisbon tsunami claimed an estimated one hundred thousand human lives. From Lisbon we move to the 2004 Mw 9.1 Sumatra–Andaman earthquake and the resultant tsunami that claimed an estimated two hundred and thirty thousand lives. By this time the science of earthquakes and tsunamis had been well established but the Indian Ocean region had relatively very few tsunamis: only three in the entire twentieth century and none of them being devastating. People were ignorant. The tsunami occurred on a Sunday morning and curiosity claimed several lives. Another important factor for the loss of the large number of human lives was the total disregard to the coastal region laws by several countries in the region that did not permit creation of infrastructure and residential properties within a stipulated distance from the high-tide line. For several countries the distance is 500 m. However, this is very often flouted in the South and Southeast Asian countries. Another factor was the holiday season when numerous tourists come to the balmy beaches of these countries. Also, an earthquake with Mw 9.1 was not expected in the region. The hypocenter was very close to heavily populated areas and there was not adequate time to respond. Moreover, the general public lacked training in defense against a tsunami. Then we had another unexpectedly large magnitude earthquake of Mw 9.0 on 11th March, 2011 in the coastal region of Japan, even though Japan is the most advanced country in the world as far as tsunami

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related research and deployment of defensive measures are concerned. The main problem was the initial underestimation of the size of the earthquake. Moreover, the tsunami walls were constructed to tackle a tsunami generated by an Mw 8 earthquake and were not tall and strong enough to handle a tsunami generated by an Mw 9 earthquake. To top all these problems was the proximity of the nuclear power plants that were damaged. It is widely accepted that but for the defensive measures undertaken by Japan, the number of human lives lost would have been much greater.

Although the science of seismology has been practiced for over 250 years, the fundamental concept of plate tectonics evolved only in the late 1960s and early 1970s. The establishment of the World Wide Standard Seismograph Network of 100+ similar seismic stations globally in the years 1963/1964 provided an opportunity of systematic global coverage of earthquake occurrence. This contributed significantly to the development of the 'Plate Tectonics Hypothesis'. All the calculations of strain accumulation and earthquake occurrence are based on the 'Plate Tectonics Hypothesis' and therefore, it is appropriate to say that rigorous work on earthquake size and location is only about 50 years old. However, in these 50 years, considerable work has been done and we believe that we understand the phenomenon of earthquake occurrence and tsunami generation a lot better now.

As far as tsunamis are concerned, significant ground has been covered in the last 8 years. One of us (HKG) very distinctly remembers that on 26th December, 2004 when the tsunami hit the Andaman and Nicobar group of islands, most of the media people in India did not know the word 'Tsunami'. In the years to follow India succeeded in setting up the 'Indian Tsunami Early Warning System (ITEWS)' with state of the art tsunami watch and warning capabilities. The two other systems that were established following the 2004 Sumatra–Andaman tsunami are the 'German-Indonesian Tsunami Early Warning System (GITEWS)' and the 'Joint Australia Tsunami Warning Center (JATWC)'. On 28th March, 2005 the Nias Mw 8.7 earthquake occurred late in the evening (9:39 pm, Indian Standard Time) and a tsunami warning was issued that caused massive evacuation on the east coast of India. No tsunami requiring evacuation occurred in the region. This caused immense inconvenience to a huge population on the east coast of India. Let us compare that situation with what happened on 11th April 2012 when two earthquakes of Mw 8.6 and 8.2 occurred within 2 h of one another. These were located close to the epicenter of the December 26, 2004 Sumatra–Andaman earthquake of Mw 9.1. The timely advisories by ITEWS, as discussed in Chap. 5, did not create any panic. Moreover, within 30 min of the occurrence of both these earthquakes, it was discovered that these were 'strike-slip' motion (Fig. 1.1) dominated earthquakes, which are not conducive for the production of a tsunami.

In the last decade, new improved methods have been developed to understand tsunami propagation. As the majority of tsunamis are caused by earthquakes, the earthquake monitoring networks based on seismological and geodetic methods, have expanded tremendously, which are not only continuously providing information about earthquake occurrence but also about the processes causing them. It is important to communicate these results to the public so that they can incorporate them into their construction activities. The laws governing construction activities

need to evolve continuously and should be implemented in a most strict manner. Effective and timely warnings about tsunamis and earthquakes and their communication to the local public can help in reducing the loss of property and lives. This will ultimately lead to a better and objective assessment of seismic and tsunami hazards so that tomorrow's world will be safer.