

## Tsunami Hazards: Public Awareness and Response in Sri Lanka

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### Abstract

The Indian Ocean Tsunami (IOT) in 2004 was one of the most destructive natural disasters in the region. The coastal regions of several countries bordering the Indian Ocean-Indonesia, Sri Lanka, India and Thailand suffered severe loss of life and damage to properties. Although tsunamis have not been considered as a natural disaster in the past, the IOT and the subsequent tsunami alerts issued in 2005, 2007, 2010 and 2012 have highlighted exposure of Sri Lanka to such hazards. As Sri Lanka is most likely to be affected by far field tsunamis as opposed to near field tsunamis, one of the most effective countermeasures would be to implement an accurate early warning system together with an evacuation system to minimize adverse impacts. The effectiveness of an early warning and evacuation system would depend on the public awareness of possible hazards and associated responses to warnings issued. Thus, a survey was conducted to assess the public awareness on tsunamis and the response to tsunami warnings issued, which was conducted in the form of a questionnaire survey in the regions affected by the IOT. The preliminary analysis of the information gathered by the survey reveals that, although the majority of the public was not aware of tsunamis as a natural hazard prior to the IOT in 2004, a large majority is now well aware of such hazards. The importance of an early warning system in the country has also been identified and an Early Warning Centre has been established with the Department of Meteorology as the focal point which has now reached the capacity of issuing an early warning within 20 minutes of a possible tsunami generating event in the Indian Ocean. The analysis also reveals that there have been favourable responses to the warnings issued with the majority of the public receiving clear warnings, evacuating to safe locations well known within 30 minutes after receiving the warning. The results of the study thus clearly reveal the effectiveness of the tsunami early warning system and the evacuation system currently in place in the country.

### Introduction

Many countries bordering the Indian Ocean experienced one of the most devastating natural disasters-the Indian Ocean Tsunami (IOT) on 26 of December 2004. The IOT was generated by a severe earthquake in the Indian Ocean, off the coast of North Sumatra, Indonesia. The earthquake measured more than 9.0 on the Richter Scale and was followed by aftershocks ranging from 6.3 to 7.0 in a zone 1,000 km north of the Andaman Islands. It caused widespread damage, both to property and human lives with over 250,000 deaths in the affected region. In Sri Lanka, the death toll exceeded 35,000.

Although, in Sri Lanka, tsunamis have not been considered as a natural hazard in the past, the IOT and the subsequent tsunami alerts issued in 2005, 2007, 2010 and 2012 have highlighted exposure of Sri Lanka to such hazards. Tsunamis can be generated by a variety of causes but the majority (more than 85 %) is caused by undersea earthquakes. When the geographical location of Sri Lanka is considered relative to the undersea earthquake prone regions, it is evident that the country is exposed to potential tsunamis generated at two such zones, the Sunda Trench located to the east and the Makran Fault located to the northwest in the Indian Ocean as indicated in Figure 1.

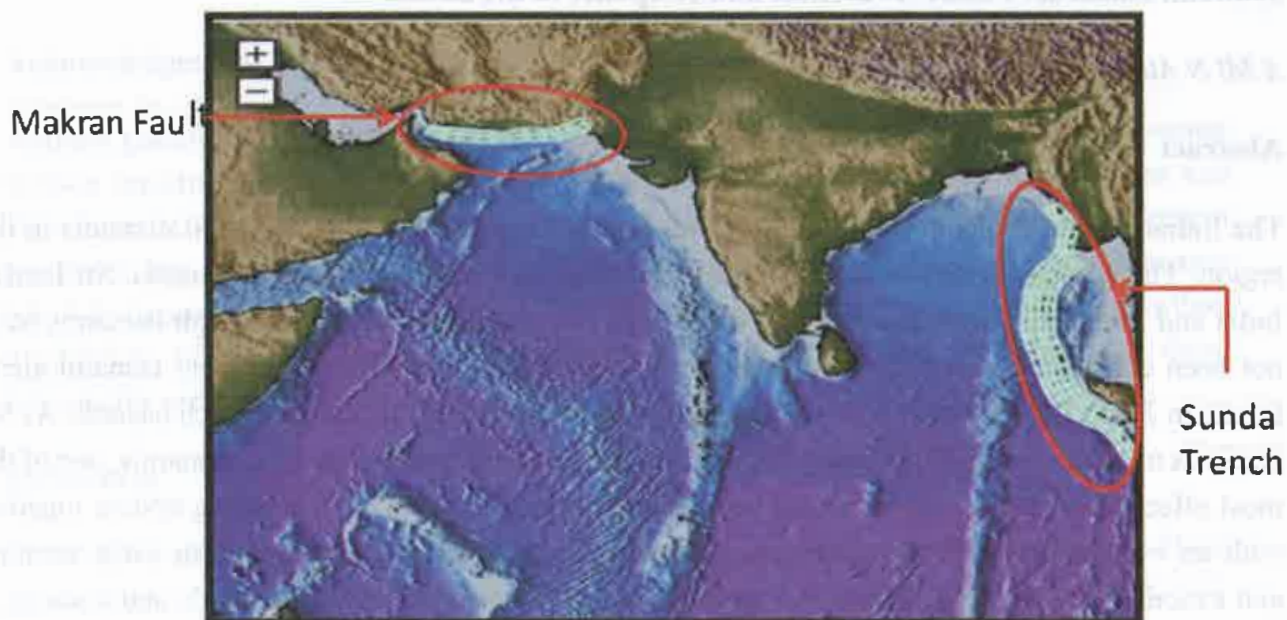


Figure 1: Sunda Trench and Makran Fault

As both the Sunda Trench located and the Makran Fault are located thousands of kilometres away from Sri Lanka, it is also evident that the country is exposed to far field tsunamis as opposed to near field tsunamis. With propagation times of far field tsunamis in excess of one hour, it is apparent that an early warning system together with an evacuation system would be effective in mitigating adverse impacts of tsunamis in Sri Lanka.

#### **Development of the Tsunami Early Warning System in Sri Lanka**

Prior to the IOT, as tsunamis had not been considered as a potential natural hazard, no tsunami early warning system existed in the country. The importance of early warning has been recognised and such a system has now been established with the Early Warning Centre (EWC) of the Department of Meteorology as the focal point.

The information related to possible tsunami generating events are received by the EWC from a variety of sources which include:

- Pacific Tsunami Warning Centre (PTWC)
- Indian Ocean Tsunami Warning System (IOTWS)
- California Integrated Seismic Network (CISN)
- United States Geographical Survey (USGS)

Alerts or advisories on Tsunami are being issued by the Department of Meteorology based on the seismic data received from the above sources (Chandradasa, U.W.L., Chandrapala, L., 2010). The decision of whether or not to issue a warning is made based on the magnitude of the earthquake occurred as given in Table 1.

Table 1: The Procedure of Issuing Warnings with respect to the Magnitude of the Earthquake

Magnitude of Oceanic Earthquake	Warning or Alert
6.5 to 6.9	EWC keeps close watch on tide gauge data available. No official bulletins are issued
7.0 to 7.4	Earthquake Information Bulletin is issued informing the occurrence of the Earthquake.
7.5 to 7.7	Earthquake Information Bulletin is issued indicating the location, magnitude of the Earthquake and requesting the public to be ready for evacuation at short notice.
Over 7.8	Tsunami Advisory Bulletin is issued requesting public in vulnerable regions to evacuate immediately

(Source: Pattiaratchi, C. (2011): "Indian Ocean Tsunami Warning System: Example from 12<sup>th</sup> September 2007 Tsunami")

Since the IOT, warnings/alerts have been issued by the EWC in 2005, 2007, 2010 and 2012. The EWC has currently reached the capability of such warnings/alerts within 20 minutes of the event of the earthquake.

It is apparent that the effectiveness of an early warning system is closely related that of the evacuation system and a favourable public response to the warning/alerts issued would be essential for the success of such a system. In view of these circumstances, a study was conducted to assess the public response to the warnings/alerts issued by the EWC, which was conducted in the form of a questionnaire survey.

### Questionnaire Survey

The questionnaire survey was conducted with the main objective of evaluating the public response to the tsunami early warnings/alerts issued by the EWC to assess the effectiveness of the tsunami early warning system and evacuation system in the country. It was conducted in the first half of 2011 and the warnings/alerts issued in 2005, 2007 and 2010 were considered. The current level of awareness on tsunami hazards was also assessed by the survey. The survey was conducted in coastal areas affected by the IOT in 2004. Coastal areas along more than 2/3 of the coastline of length 1600 km were affected by the IOT as indicated in Figure 2.

An important aspect of the questionnaire was that, for many questions, the participants had the opportunity of providing answers from their knowledge as opposed to selecting an answer from a given set of alternatives. Although this meant a severe demand with respect to time in conducting





The analysis of data indicated that the majority, 76 %, of the public in the country was not aware of tsunamis prior to the IOT in 2004 as indicated in Figure 3. However, as indicated in the Figure 4, a large majority, 77 %, is currently aware of undersea earthquakes as the most common of tsunamis. Although to a much lesser extent, the public was also aware of the other potential causes of tsunamis. The results indicate that only a minority of the public, 16 %, was not aware of the causes of tsunami generation. A large majority, 78 %, was aware of the difficulty in predicting potential tsunamis in the future. As indicated in Figure 5, a variety of tsunami impact mitigation measures was identified by the public. The majority, 63 %, identified the early warning system as an effective mitigation measure.

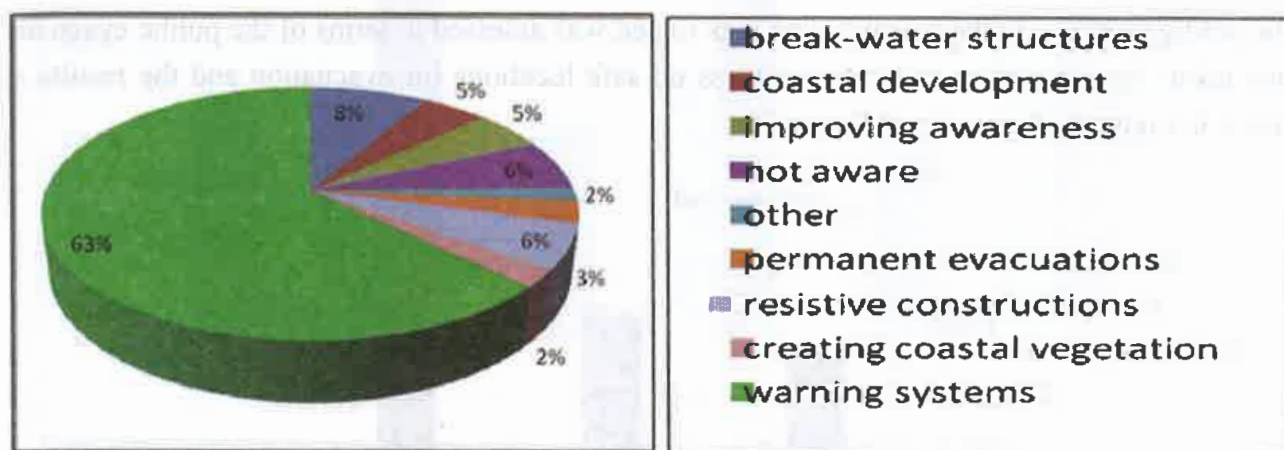


Figure 5: Tsunami Impact Mitigation Measures identified by the Public

### Effectiveness of the Early Warning System

The % of public receiving the warning issued, its clarity and the mode of receiving were considered in the assessment of the effectiveness of the warning system. The results of the relevant analysis are shown in Figure 6 and Figure 7.

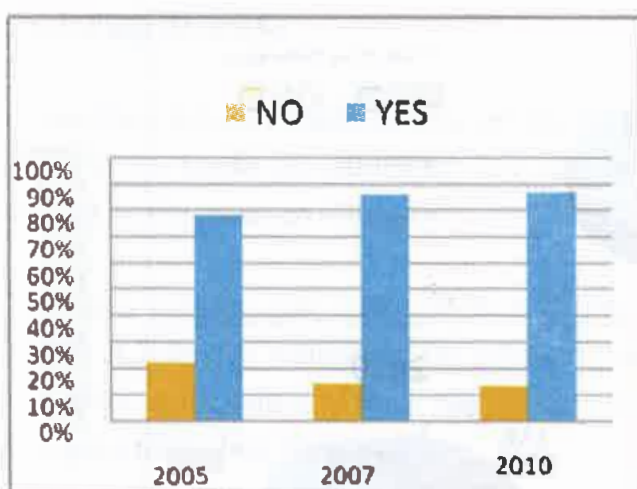


Figure 6: % of Public receiving the Warning

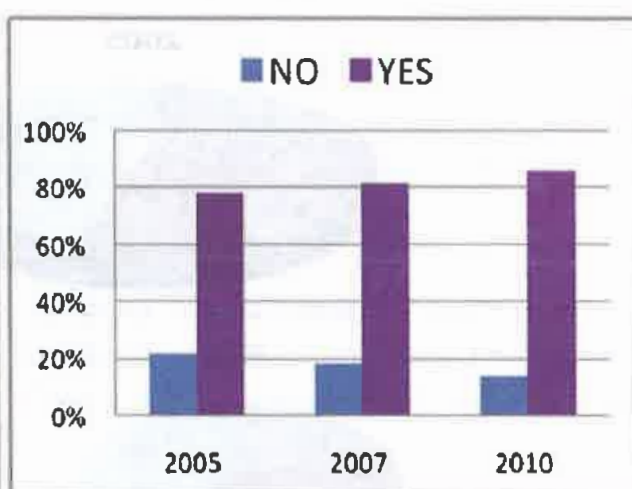


Figure 7: Clarity of the Warning

It is evident from the results shown in Figure 6 that the warning has been received by a majority of more than 70 % of the public in all three occasions. The clarity of the warning was also confirmed by a majority in the order of 80 % in all three occasions. The warning has been conveyed by a variety

of modes and the results indicated that the electronic media/communications (radio, television and telephone) as the predominant mode through which the majority, 67 % in 2005, 48 % in 2007 and 58 % in 2010, received the warning. The social interaction of the communities also played an important role with a significant % of the public, 28 % in 2005, 46 % in 2007 and 23 % in 2010, receiving the warning from the neighbours. The police has also played an increasing role with 1 % of the public in 2005, 5 % in 2007 and 15 % in 2010 receiving the warning through police communications.

**Public Response**

The public response to the tsunami warnings issued was assessed in terms of the public evacuated, time taken for evacuation and the awareness on safe locations for evacuation and the results are shown in Figure 8, Figure 9 and Figure 10.

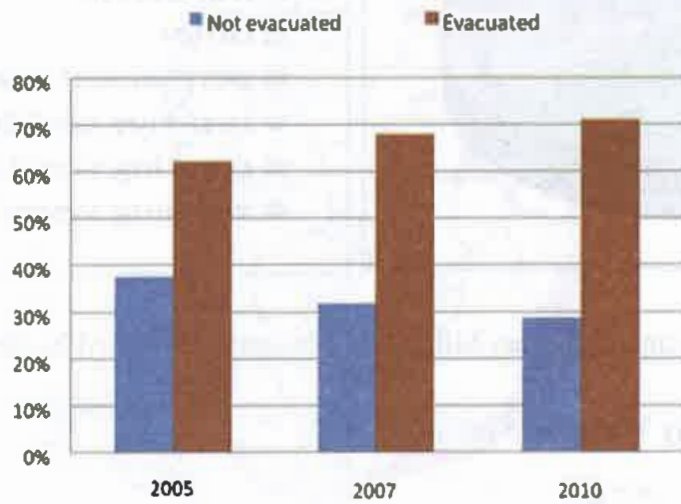


Figure 8: % of Public Evacuated

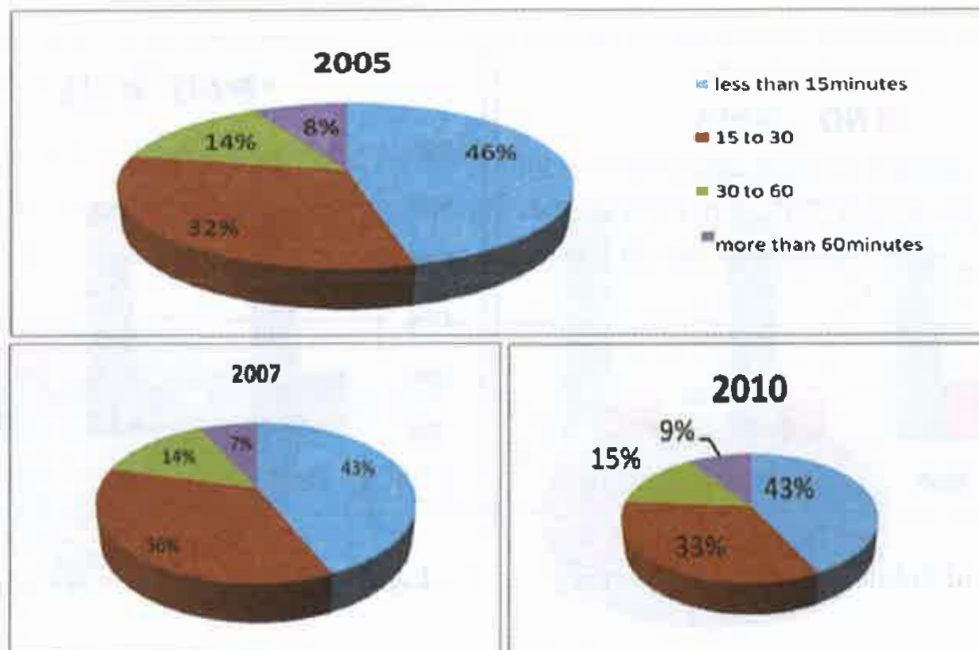


Figure 9: Time taken for Evacuation



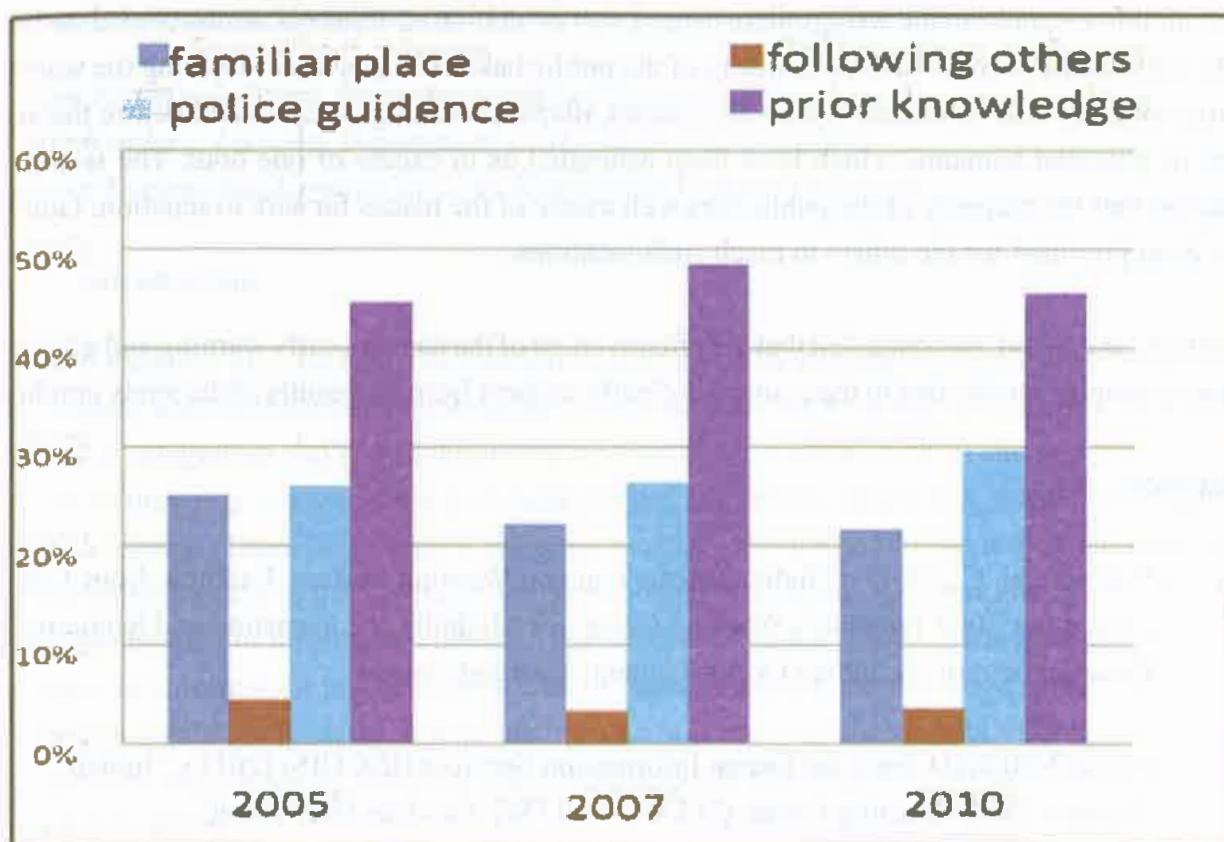


Figure 10: Safe Locations of Evacuation

As indicated in Figure 8, the majority of public (62 % in 2005, 68 % in 2007 and 71% in 2010), has evacuated within 30 minutes (78 % in 2005, 79 % in 2007 and 76 % in 2010 as indicated in the Figure 9) after receiving the warning. The majority of the public (70 % in 2005, 70 % in 2007 and 67 % in 2010 as indicated in the Figure 10), was also aware of places of evacuation. A favourable public response to the warnings issued is thus revealed by the results.

### Concluding Remarks

The results of a study conducted to assess the effectiveness of a tsunami early warning and evacuation system in Sri Lanka are presented. The current level of awareness on tsunami hazards was also assessed by the study.

The results indicate that, although the majority of the public was not aware of tsunamis prior to the IOT in 2004, the majority of the public is now well aware of such a hazard with a high level of knowledge on the causes of tsunamis, the difficulty in predicting the tsunami events in the future and the impact mitigation measures.

The effectiveness of the early warning system was also evident from the results of the study. The majority of the public has received clear warnings/alerts on all three occasions of such warnings/alerts were issued in 2005, 2007 and 2010. The electronic media/communications have played the dominant role in conveying the warnings/alerts issued followed by social interactions. The increasingly significant role played by the police was also evident from the results.

A favourable response to the wrings/alerts issued was evident in all three occasions considered in the study. The results indicate that the majority of the public has evacuated after receiving the warnings. A large majority had evacuated within 30 minutes after the warnings were issued before the arrival times of potential tsunamis which have been estimated as in excess of one hour. The results also indicated that the majority of the public was well aware of the places for safe evacuation. Guidance have been provided for the others to reach such locations.

It can thus, in general, be concluded that the effectiveness of the tsunami early warning and evacuation system currently established in the country is clearly evident from the results of the study conducted.

## References

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