Ocean Decade Tsunami Programme

Research & Development Implementation Plan

Executive Summary

13 February 2023

1 Introduction

Tsunamis are one of the deadliest oceanic hazards, which can arrive in minutes or hours, many times without notice, and have the potential to impact an entire ocean basin. They are caused by the displacement of large volumes of water due to an undersea earthquake, a submarine landslide, a volcanic eruption, meteorological disturbances or a meteorite impact. Between 1992 and 2019, 295 confirmed tsunamis were observed worldwide. Thirty-five of these resulted in loss of life. We do not know when and where the next tsunami will hit, but we know the impacts can be devastating.

The Indian Ocean Earthquake of 26 December 2004 caused one of the largest and most disastrous tsunamis ever experienced. An estimated 230,000 people lost their lives in 14 countries and resulted in damages of an estimated USD10 billion. The highest death toll, of about 130,000, was reported from Banda Aceh and Meulaboh along the north-western coast of Sumatra where the tsunami heights exceeded 30 m. Within hours the tsunami propagated to all directions of the Indian Ocean affecting Thailand, Sri Lanka, India, Maldives and as far as east Africa. A few years later, on 11 March 2011, a very large earthquake ruptured offshore NE Japan in the Pacific Ocean and generated a tsunami, which devastated the Northeast (NE) coastal zone of Japan, particularly the Tohoku region where the maximum heights reached up to about 20 m, while the tsunami penetrated inland up to about 5 km. Nearly 20,000 people lost their lives including missing persons, nearly 90 percent of them due to the tsunami. The tsunami also caused major damage to the Fukushima nuclear power station. A nuclear accident took place in direct connection with this event. Within hours the tsunami propagated throughout the Pacific Ocean affecting as far remote regions as California, where damage occurred was noted in Crescent City and several other harbours.

The 2018 Palu and Anak Krakatoa, and 2022 Hunga Tonga - Hunga Ha'apai events further illustrated the challenges of current Tsunami Warning Systems locally and globally. These three events are cataloged as "non-seismic tsunamis" as they were not caused by subduction earthquakes, and thus posed a challenge on current tsunami warning protocols. The tsunami caused by the eruption of the Hunga Tonga - Hunga Ha'apai volcano in 2022 affected the entire Pacific basin, causing two deaths in Peru and was recorded at other basins like the Caribbean and Mediterranean Sea.

These events call for enhanced coordinated national and international efforts for the Tsunami Warning Systems to account for all tsunamis and to prepare people to respond to all tsunamis. The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) was given the United Nations (UN) mandate to establish global tsunami warning services operating in different ocean basins: the Pacific Tsunami Warning and Mitigation System (PTWS), the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS), the North-eastern Atlantic, the Mediterranean and Connected Seas Tsunami Warning System (NEAMTWS), and the Caribbean and Adjacent Regions Early Warning System (CARIBE-EWS), each coordinated by a regional Intergovernmental Coordination Group (ICG). One of the primary goals of all ICGs is to coordinate and enhance tsunami monitoring, early warning and community response.

2 The Ocean Decade Tsunami Programme

In 2016, IOC-UNESCO initiated the concept, the “Ocean we have” to the “Ocean we want” and in December 2017, this concept culminated in the proclamation of the UN Decade of Ocean Science for Sustainable Development (2021–2030), also referred to as the Ocean Decade. The Ocean Decade’s primary objective is to harness, stimulate and empower interdisciplinary ocean research at all levels to support the timely delivery of the data, information and knowledge needed to achieve a well-functioning ocean in support of all Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development. The Ocean Decade will also contribute data, information and knowledge in support of the Sendai Framework for Disaster Risk Reduction 2015-2030.

In June 2021, IOC-UNESCO approved the Ocean Decade Tsunami Programme (ODTP) in response to the call of action by the Ocean Decade and in particular, to significantly enhance the existing global tsunami warning system by reducing timeliness and the uncertainty of the tsunami warning, and increasing the readiness of coastal communities, with the ultimate goal of minimising the loss of lives.

The **first objective of the ODTP** is to develop the warning systems’ capacity to send out actionable warnings within 10 minutes for tsunamis from all sources with the least amount of uncertainty, in order to evacuate the largest possible amount of endangered people before impact. To achieve this 10-minute target requires expanding existing monitoring systems and implementing further scientific and technological advances (Sumy et al., 2022).

The second objective of the ODTP is that 100 percent of communities at risk to be prepared and resilient to tsunamis by 2030 through programmes like the IOC-UNESCO Tsunami Ready Recognition Programme (TRRP), which was approved by the IOC-UNESCO Executive Council in 2022. It embodies 12 Assessment, Preparedness and Response Indicators that support communities at risk to build capacities to effectively respond to warning and tsunami threats.

The ODTP will be a decisive contribution to the implementation of the SDGs, not only SDG 14 (the ”Ocean” SDG), but many other goals as well. The means of implementing targets under each SDG is a global partnership supported by concrete policies and planning. National policies and local implementation strategies should support global planning. The ODTP Research and Development Plan adopts the SDGs strategies in global planning, pursuing them through national policies and local implementation at the community level.

Implementation of the Research and Development Plan will also need to ensure special consideration, and priority is given to addressing and supporting the needs of Small Island Developing States (SIDS) and Least Developed Countries (LDCs).

3 Elements of Early Tsunami Warning and Challenges

Early Warning Systems include four pillars (UNDRR, 2009): (i) Tsunami Disaster Risk Knowledge, (ii) Detection, Monitoring, Analysis and Forecasting of the tsunami hazard and possible consequences (iii) Warning Dissemination and Communication and (iv) Preparedness and Response Capabilities. These four components are underpinned by capacity development and governance.

3.1 Tsunami Risk Assessment

Understanding the risk and developing a plan to mitigate this risk is what saves lives. While tsunamis are infrequent and catastrophic ones are rare, the historical record shows that tsunamis have the potential to hit every coast around the world – we don't know when, where, or how big. Also, it is important to evaluate the geological history of tsunami-prone areas to identify the probable communities at risk. This evidence will be useful to these communities, to mitigate the loss during the next.

Until recently only seismic sources were considered in Tsunami Hazard Assessment studies and operational warning procedures. This has been the case because seismic-originated tsunamis are the vast majority impacting near and far-field coasts. On the other hand, most non-seismic tsunamis have limited and localized areas of high impact. However, impacts related to recent events have highlighted the importance of non-seismic tsunamis. Hazard assessments should also include all possible tsunami sources affecting the interest areas, and not only seismic sources.

3.2 Detection and Warning

A dense observation network plays a crucial role in the quick detection of the earthquake and its potential to generate a tsunami. Based on observations, the warning system determines whether communities are to be evacuated from the tsunami-prone areas, and if so, when they should be allowed to return. However, in the case of a local tsunami where the estimated tsunami arrival time to the nearest coast is less than 15 minutes, it is important to educate the community about physical signs of the tsunami such as long ground shaking, approaching roaring sound, rapid withdrawal of the water, etc. It is challenging to generate an accurate tsunami forecast in a short amount of time in the case of major earthquakes with ruptures that reach hundreds of kilometres.

To improve the tsunami detection and more accurate tsunami threat assessment and impact forecast, Member States identified the requirement for denser real-time, multi-faceted sensor networks and faster, integrated algorithms to quickly characterize the tsunami source (seismic and atypical sources) and compute tsunami inundation forecasts for their coasts. Sensors include singly or array-deployed high-quality seismometers and accelerometers, coastal sea level gauges and deep-ocean pressure systems such as Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys, dedicated seafloor observatories and trans-basin undersea cables such as Science Monitoring and Reliable Telecommunications (SMART) cables, and Global Navigation Satellite System (GNSS) land and sea elevation buoys. High-resolution coastal bathymetry and topography or Digital Elevation Model (DEM) contributions are also highly significant, for example, the Nippon Foundation-GEBCO SEABED 2030 project. New data and methods, for both seismic and non-seismic sources, are needed to more precisely characterize rupture complexities of very large earthquakes within a few minutes to produce more accurate tsunami forecasts from numerical models.

In summary, the warning system must identify, monitor, and forecast the risk at the earliest possible time, and it can be achieved when the system is built based on risk awareness, emergency preparedness, and early warnings. Then the warning must be generated, delivered, received, and utilized in a timely, complete, and accurate manner.

3.3 Warning Dissemination

Tsunami warnings and evacuation advice are only effective when it reaches a person on the coast in time before a destructive wave hits. Both the dissemination (its timeliness and reliability) and the communication of the advice (what the message says) must be successful and actionable, or lives may be unnecessarily lost. The warning dissemination includes organisational and decision-making processes, and redundant communication systems in place and operational. Additionally, incorporating tsunami warning dissemination (which may be infrequent) into multi-hazard communication systems will help to ensure sustainability and readiness.

Clear messages conveying basic, practical, and usable information are essential to ensure the proper readiness of communities. For quicker forecast results, we need to deal with larger uncertainties; with this complexity, building community trust takes longer. Also, it is a basic and practical requirement to establish communication platforms in pre-identified regional, national, and local channels by authorities. To ensure that as many people as possible are alerted, to prevent the failure of any one channel, and to reinforce the warning message, numerous communication channels must be used. To convey warnings, alerting authorities employ a variety of standards and protocols, for example, the recent development, Common Alerting Protocol (CAP), is an international format for public warning and emergency alerting created by the International Telecommunication Union and supported by several organisations.

3.4 Preparedness and Response Capabilities

As disasters are foremost local, coastal communities will suffer the brunt of the impact from the next tsunamis. Adding to the challenge, ocean-wide tsunamis are infrequent; before memories of the last tsunami fade away, we must put more effort into creating awareness and preparedness. In order to be successful, we will need continuing and enhanced engagement from governments, research institutes and universities, industry, communities, the media, and other interested parties. In an end-to-end warning system, the communities at risk must be aware of how to respond quickly after receiving warnings; it is equally important as detection and warning.

The IOC-UNESCO Tsunami Ready Recognition Programme is a strong example of initiatives that motivates communities to take common-sense preparedness actions, which include hazard assessment, inundation and evacuation mapping, awareness and education and exercises. It includes preparedness measures, such as response plans developed and operational, public awareness and education campaigns conducted, and public awareness and response tested and evaluated. Tsunami Ready is identified by most Member States as a priority activity. Novel initiatives like the Blue-Line project around New Zealand coastlines may also be disseminated in the context of Tsunami Ready. Finally, World Tsunami Awareness Day (WTAD) on 5 November is also mentioned by Member States as a means of increasing awareness and preparedness. The implementation of such initiatives is key to increasing tsunami preparedness and response.

4 Governance

4.1 Tsunami Warning in a Multi-Hazard Framework

Tsunami waves frequently originate from cascading effects, such as earthquake-landslide-tsunami, volcanic eruption-earthquake-tsunami, and others. Even when the fault displacement connected to the earthquake does not produce a tsunami, a powerful coastal or undersea earthquake may trigger a landslide that acts as a generator of tsunami. The 2011 Tohoku earthquake and tsunami in Japan is a striking example of the cascading effects of tsunami due to which nuclear power plants meltdown happened. The other examples of cascading effects are, storm surge during tsunami, coastal erosion which may impact tsunami wave approach after reaching the coast, increase in rainfall rate in coastal areas can directly influence landslides, triggering tsunami. Also, recently, studies have been conducted on possible effects that climate change may have on the long-term assessment of the tsunami hazard and, consequently, of the tsunami risk. Therefore, it is important to consider the potential for cascading impacts in locations that are vulnerable to these kinds of processes in pertinent investigations.

After the 2004 Indian Ocean Tsunami, most of the Member States have developed their national tsunami warning systems. However, these warning systems are designed for single hazards and rarely integrated as a multi-hazard system. For example, in the case of oceanic hazards, after the 2004 tsunami, many Member States established tsunami early warning centres, but early warning systems for storm-surges are not an integral part of tsunami warning systems and are still under development by many countries. Also, the warning system for harmful algal blooms, coral reef bleach and oil spills, etc., are still at very early stages in many Member States and mostly operated under different operational agencies which are not interconnected. The need to improve and harmonize the warning systems including and beyond hydrometeorological hazards is widely acknowledged and is reflected in the Sendai Framework for Disaster Risk Reduction.

To support redundancy, consistency, and accessibility, the focus must be on multi-hazard early warning alignment by linking hazard-specific systems together. It is especially necessary in LDCs and SIDS, where there still remain significant gaps in application of advances in scientific knowledge and reach to local endangered populations. This applies to resources, capacity, information, Standard Operating Procedures (SOPs), etc. When an individual hazard warning system is brought under the multi-hazard framework, the coordination becomes much easier, the resources can be utilized optimally, and the information can be effectively used for hazard mitigation. The resulting societal benefits of early warning systems can thus be spread evenly across regions, countries and communities.

4.2 Inclusiveness, gender diversity and youth involvement

The ODTP will apply an inclusive approach to governance, providing a balanced platform for gender and generational participation. To be inclusive requires the needs, perspectives, priorities, and meaningful participation of the many different people in society. Marginalised people are often overlooked by early warning systems and require special consideration and focused attention. Gender discrimination and lack of diversity limits the access of women and girls to information, resources, and opportunities, increasing their exposure to risk, and loss, and disruption of livelihoods during disasters. Youth, young professionals, and early career researchers should be fully engaged as they can bring new energy, initiatives and approaches that will contribute to the adoption and innovation for early warning systems. Furthermore, their early engagement will also help to reduce the inter-generational gap and ensure the continuity of the system.

5 Capacity Development

Alongside the development of technical solutions, the development of individual and institutional capacity is required. Capacity currently varies across regions, countries and communities, as well as across genders and generations. The aim is to have equitable access to data, information, knowledge, technology, and infrastructure, leaving no-one behind. To support the objectives of the ODTP our scientific knowledge of tsunamis and social behaviour must continue to develop. This will require enhanced research capacity and transfer of technology.

Many SIDS and LDCs are more vulnerable and exposed to tsunami risk than other countries. Many of these countries also lack staff and/or their staff do not have the scientific and technical capacity to effectively support and enhance their tsunami warning system. Therefore, the implementation of the Research and Development Plan will need to ensure special consideration and priority is given to addressing and supporting the capacity needs of SIDS and LDCs. This will both ensure a high level of local preparedness, as well as address important gaps in the global tsunami warning system.

6 Pathways to Implementation

The IOC-UNESCO tsunami programme will oversee the overall implementation of the ODTP through contributions and engagement of Member States, in coordination with the ICGs, and with the collaboration of academic institutions, researchers, industry, philanthropic organisations and other stakeholders.

Considering the nature of tsunami hazard, the optimal solutions should have a global design, address regional imperatives, and be implemented through contributions and actions of Member States and other stakeholders. The ODTP will provide a framework for identifying gaps, suggesting solutions, prioritise resources, and implementing actions within the timeframe of the Ocean Decade.

It is recognized that not all Member States or national activities have resources to make substantial investments in risk assessments, observing and warning infrastructure, communications and preparedness and response. It is therefore the intent of the plan to offer contribution pathways that cover the full spectrum or financial commitment by targeting the objectives most important to advancing Member State capabilities.