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2024 IOTWMS Capacity Assessment of Tsunami Preparedness in the Indian Ocean

Summary Report

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2024 IOTWMS Capacity Assessment of Tsunami Preparedness in the Indian Ocean

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BACKGROUND

The devastating Indian Ocean Tsunami (IOT) of 26 December 2004 resulted in over 230,000 people losing their lives and more than a million people displaced from their homes (Figures 1 and 2). At that time there was no regional tsunami warning system in the India Ocean. Only a few countries had a capability to provide very basic national alerts to their communities.

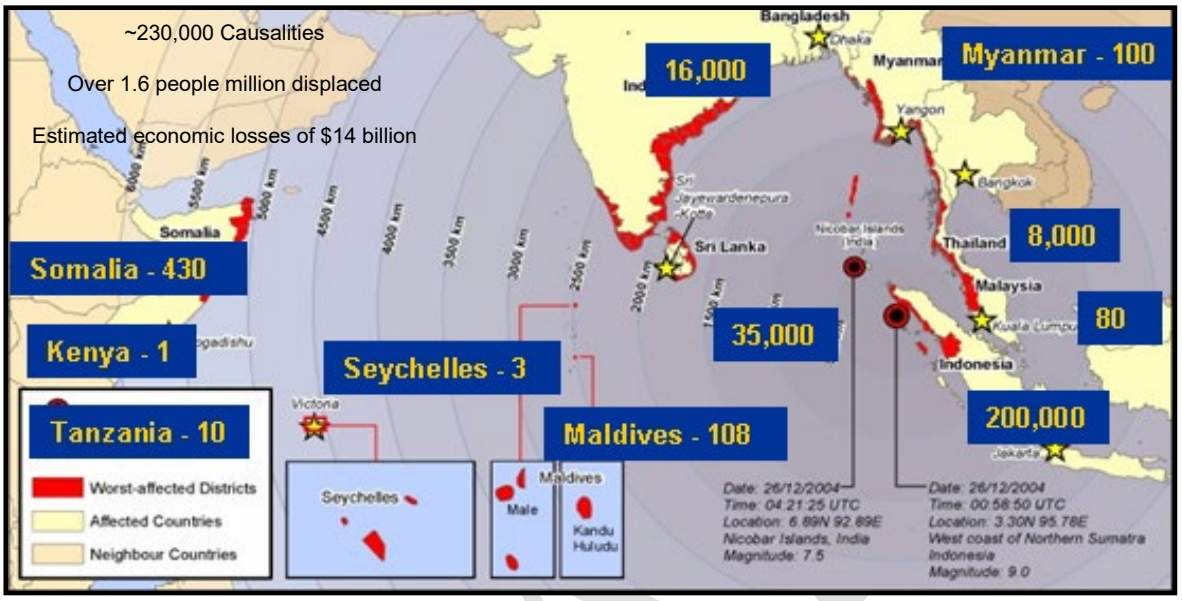


Figure 1: Approximate deaths and damage caused by Indian Ocean Tsunami on 26 December 2004

Figure 2: Some of the devastation in 2004 in Banda Aceh, Indonesia, close to tsunami source.

The Indian Ocean has experienced 33 more tsunami events across the Indian Ocean since 2004, of which seven have taken lives (Table 1). While most of the tsunami events across the Indian Ocean have been due to subduction earthquakes, the two devastating events in 2018 in Sulawesi and Anak Krakatau in Indonesia were due to submarine landslides and a volcano flank collapse respectively. This highlights the risk from

Table 1: Tsunami events in Indian Ocean since 2004 (*Source NOAA NCEI, USA*)

Date	Location	Cause	Countries impacted	Deaths (estimate)
26/12/2004	Off W. Coast of Sumatra	Mag. 9.1 earthquake	Indian Ocean	227,899
28/03/2005	W. Coast N. Sumatra, Indonesia	Mag. 8.6 earthquake	Indonesia	16
04/10/2005	Kepulauan, Mentawai, Indonesia	Mag. 6.7 earthquake	Indonesia	
14/03/2006	Seram Island, Indonesia	Mag. 6.7 earthquake	Indonesia	4
17/07/2006	South of Java, Indonesia	Mag. 7.7 earthquake	Indonesia,	802
12/09/2007	Sumatra, Indonesia	Mag. 8.4 earthquake	Indonesia	
25/02/2008	Sumatra, Indonesia	Mag. 6.5 earthquake	Indonesia	
16/11/2008	Sulawesi, Indonesia	Mag. 6.5 earthquake	Indonesia	
03/01/2009	Near N. Coast of Indonesia, Indonesia	Mag. 7.6 earthquake	Indonesia	
03/01/2009	Near N. Coast of Indonesia, Indonesia	Mag. 7.3 earthquake	Indonesia	
11/02/2009	Celebes Sea, Indonesia	Mag. 7.3 earthquake	Indonesia	
02/09/2009	Java Sea, Indonesia	Mag. 7.3 earthquake	Indonesia	
30/09/2009	Sumatra, Indonesia	Mag. 7.5 earthquake	Indonesia	
06/04/2010	Sumatra, Indonesia	Mag. 7.8 earthquake	Indonesia	
12/06/2010	Little Nicobar Island, India	Mag. 7.5 earthquake	India	
25/10/2010	Mentawai, Sumatra, Indonesia	Mag. 7.8 earthquake	Indonesia	431
11/04/2012	Off W. Coast N. Sumatra, Indonesia	Mag. 8.6 earthquake	Indonesia	
11/04/2012	Off W. Coast N. Sumatra, Indonesia	Mag. 8.2 earthquake	Indonesia	
24/09/2013	Off Coast Gwadar, Pakistan	Mud volcano creation	Pakistan, Iran	
15/11/2014	N. Moluccas Islands, Indonesia	Mag. 7.1 earthquake	Indonesia	
02/03/2016	SW Sumatra, Indonesia	Mag. 7.8 earthquake	Indonesia	
28/07/2018	Bali Sea, Indonesia	Mag. 6.4 earthquake	Indonesia	
05/08/2018	Bali Sea, Indonesia	Mag. 6.9 earthquake	Indonesia	
19/08/2018	Bali Sea, Indonesia	Mag. 6.3 earthquake	Indonesia	
28/09/2018	Sulawesi, Indonesia	Mag. 7.5 earthquake/ submarine landslide	Indonesia	4340 tsunami + earthquake
22/12/2018	Anak Krakatau Volcano, Indonesia	Volcanic eruption	Indonesia	437
02/08/2019	W. Java, Indonesia	Mag. 6.9 earthquake	Indonesia	
14/11/2019	N. Moluccas Islands, Indonesia	Mag. 7.1 earthquake	Indonesia	
29/05/2020	Lesser Sunda: Bali: Ijen Volcano, Indonesia	Volcanic eruption	Indonesia	
16/06/2021	Banda Sea, Indonesia	Mag. 5.8 earthquake	Indonesia	
14/12/2021	Flores Sea, Indonesia	Mag. 7.3 earthquake	Indonesia	
09/01/2023	S. Maluku, Indonesia	Mag. 7.3 earthquake	Indonesia	
24/04/2023	SW. Sumatra, Indonesia	Mag. 7.3 earthquake	Indonesia	

tsunamis also generated by non-seismic and complex sources, which is the current focus of further development of tsunami hazard assessment, warning, and mitigation globally [1].

There are two main sources of tsunami threat in the Indian Ocean (Figure 3). While the 2004 IOT and most tsunamis are generated by the Sumatra earthquake subduction zone in the eastern Indian Ocean, there is a similar threat from the Makran Source Zone in the NW Indian Ocean. In 1945 [2] over 4000 people lost their lives due to a tsunami generated in this zone.

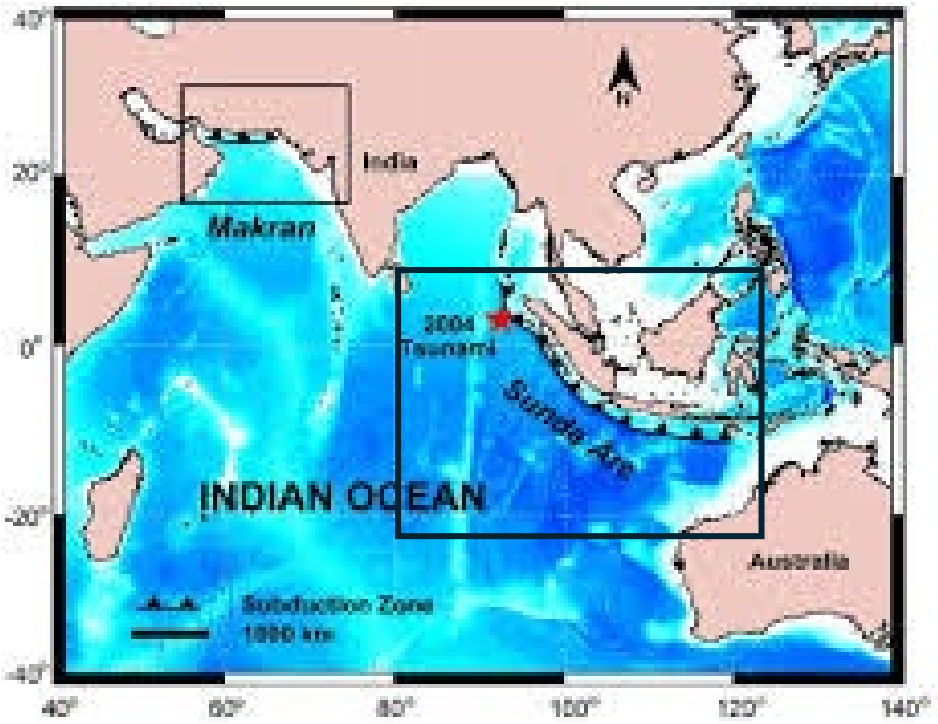


Figure 3: Two main subduction earthquake zones for generating tsunamis in the Indian Ocean

In 2005, the 2nd United Nations (UN) World Conference on Disaster Risk Reduction (WDCRR) – held in Kobe, Japan – and the Ministerial Meeting on Regional Cooperation on Tsunami Early Warning Arrangements – held in Phuket, Thailand – garnered increased international attention following the 2004 Indian Ocean tsunami. Over 130 countries and territories globally joined forces to better mitigate tsunami risks and prepare communities in the face of these otherwise unpredictable events. UNESCO's Intergovernmental Oceanographic Commission (IOC) was subsequently given the mandate by the United Nations General Assembly (UNGA) to coordinate the establishment of a global tsunami warning and mitigation system.

Resolutions XXIII-12, XXIII-13, and XXIII-14 of the 23rd Session of the UNESCO-IOC General Assembly created the UNESCO-IOC Tsunami Programme (see tsunami.ioc.unesco.org), which includes tsunami warning and mitigation systems in the Indian Ocean, Pacific Ocean, Caribbean and adjacent regions, North-Eastern Atlantic, Mediterranean and connected seas.

[1] UNESCO-IOC. 2024. Monitoring and Warning for Tsunamis Generated by Volcanoes. 2024. Paris, UNESCO. (IOC Technical Series No.183)
[2] UNESCO-IOC. 2015. Remembering the 1945 Makran Tsunami – Interviews with Survivors Beside the Arabian Sea. 2015. Paris, UNESCO. (IOC Brochure 2015-1)

As one of the initial steps, UNESCO-IOC in 2005 facilitated an assessment of capacity development requirements [3] to build an effective and durable tsunami warning and mitigation system in the Indian Ocean. This was facilitated by Expert Missions to 16 of the 25 Member States identified as in particular requiring capacity development. The UNESCO-IOC PTWS was used to identify the basic requirements.

In August 2005, UNESCO-IOC established the Intergovernmental Coordination Group (ICG) for the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS). Its primary role was to coordinate the efforts of Member States around the Indian Ocean to build the IOTWMS and support its ongoing implementation [4]. It is supported by the UNESCO-IOC ICG/IOTWMS Secretariat (funded by the Government of Australia).The UNESCO-IOC ICG/IOTWMS meets at least every two years and is supported by the UNESCO-IOC ICG/IOTWMS Secretariat (funded by the Government of Australia). It is organised according to three strategic pillars: 1) Hazard and Risk; 2) Detection, Warning, and Dissemination; and 3) Community Awareness and Preparedness.

The UNESCO-IOC IOTWMS was quickly established, with the main objective to alert countries all around the Indian Ocean of any future threats. It was initially based on the Pacific Tsunami Warning & Mitigation System (PTWS), which had been established by UNESCO's IOC in 1965 following the tsunami generated by the 1960 earthquake in Chile that devastated many countries around the Pacific Ocean in 1960. One of the first tasks of the ICG/IOTWMS was to establish an Interim Alert Systems (IAS), which was quickly implemented in 2005 by the Government of United States of America and the Government of Japan, utilising their expertise in the PTWS. National Tsunami Warning Centres (NTWCs) were established by each country.

By 2011 the independent regional tsunami threat forecasting capability of the IOTWMS was fully implemented. Designated UNESCO-IOC Tsunami Service Providers (TSPs) were established by Australia, India, and Indonesia to provide tsunami threat information to the NTWCs. The NTWCs review the interoperable information provided by each TSP for the entire Indian Ocean region and decide and issue warnings to their at-risk communities.

After a period of parallel operation and cross-evaluation of the new system, the IAS ceased operation in 2013. The IOTWMS is now extensively exercised every two years (2009, 2011,2014, 2016, 2018, 2020, 2023) in IOWave Exercises coordinated by the UNESCO-IOC ICG/IOTWMS and supported by the UNESCO-IOC Secretariat. Member States are also encouraged to conduct national exercises during the in-between years.

At its 10th Session (Muscat, August 2015), the ICG/IOTWMS identified the need to conduct a reassessment of the state of tsunami preparedness of the Indian Ocean Member States. This was to help evaluate progress since the 2004 IOT, as well as identify remaining gaps and prioritise capacity development requirements at both the regional and national level for strengthening the end-to-end tsunami warning and mitigation system.

At its 11th Session (Putrajaya, April 2017) the ICG/IOTWMS established the inter-sessional "Task Team on Capacity Assessment of Tsunami Preparedness" (TT-CATP) to oversee the capacity assessment of tsunami preparedness of the IOTWMS. The Task Team was chaired by Dr. Harkunti Rahayu (Indonesia) with representatives from Australia, India, Indonesia, Oman, Malaysia, UNESCO-IOC Indian Ocean Tsunami Information Centre (IOTIC), the ICG/IOTWMS Working Groups and Task Teams, and invited experts from the Global Disaster Resilience Centre of the University of Huddersfield, U.K. The TT-CATP designed an extensive online survey covering all pillars and aspects of the end-to-end tsunami warning and mitigation system. The online questionnaire was built upon the ICG/IOTWMS National Report Template, Post-IOWave Exercise Surveys, and UNESCO-IOC Post-Event Assessment Surveys[5].

[3] UNESCO-IOC; UN-ISDR/PPEW; WMO. Assessment of Capacity Building Requirements for an Effective and Durable Tsunami Warning and Mitigation System in the Indian Ocean: Consolidated Report for 16 Countries Affected by the 26 December 2004 Tsunami. Paris, UNESCO 2005. IOC Information Document No. 1219

[4] Indian Ocean Tsunami Warning and Mitigation System IOTWS. Implementation Plan, Sixth Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-V), Hyderabad, India, 7-9 April 2009, IOC Technical Series No. 71. (Revision 2), UNESCO 2009

[5] International Tsunami Survey Team (ITST) Post-Tsunami Survey Field Guide. 2ndEdition. IOC Manuals and Guides No.37, Paris: UNESCO 2014(English)

In 2018, a total of 20 ICG/IOTWMS Member States responded to the reassessment survey. The results [6] [7] provided a new baseline of the status of tsunami preparedness capacity in the region, including capacity development requirements at both regional and national levels. The results clearly indicated that there had been considerable improvement across all components of the IOTWMS since the previous assessment in 2005, but much work was still required, especially with regards to preparedness at the vulnerable community level. The recommendations from the 2018 assessment provided core input into the development of the work programmes of the ICG Working Groups and Task Teams.

The work programmes related to the three pillars of the ICG/IOTWMS are currently managed by the following groups, with members elected by the ICG: Working Group 1 – Tsunami Risk, Community Awareness and Preparedness; Working Group 2 – Tsunami Detection, Warning, and Dissemination; Working Group 3 – Tsunami Ready Implementation; Regional Working Group - North-West Indian Ocean; and Task Team on IOWave23 Exercise. A Steering Group coordinates the work programmes decided by the ICG. It advises the ICG Chair, who is formally elected by the Member States of the ICG, on any decisions in the intersessional period. The Steering Group consists of the ICG Officers (ICG chair and two ICG vice-chairs), chairs and vice-chairs of the working groups and task team. It also has representatives of the three UNESCO-IOC Tsunami TSPs, and two Member States representing NTWCs. The Member States and Steering Group are further supported by the UNESCO-IOC Indian Ocean Tsunami Information Centre (IOTIC: funded by Government of the Republic of Indonesia).

As 2024 marks the 20th anniversary of the 2004 IOT, the UNESCO-IOC ICG/IOTWMS at its 13th Session (Bali, November 2022) (Figure 4) decided it was timely to conduct the next reassessment of the state of tsunami preparedness in ICG/IOTWMS Member States. An *Ad Hoc* Task Team 2024 IOTWMS Capacity Assessment Tsunami Preparedness (CATP) was subsequently established under Working Group 3 Tsunami Ready Implementation. The outcomes from the assessment will inform the 2nd Global Tsunami Symposium (Banda Aceh, November 2024) on progress since the IOT of 2024. The results are also for consideration by Member States at the 14th Session of the ICG/IOTWMS (Jakarta, November 2024) to develop work programmes to address remaining gaps, and for potential donors to support the identified capacity building needs. This assessment will inform the development of the ICG/IOTWMS Medium-Term Strategy for 2025-29.

Figure 4: 13th Session ICG/IOTWMS, Bali, Indonesia. November 2022

[6] UNESCO-IOC. 2020. Capacity Assessment of Tsunami Preparedness in the Indian Ocean – Status Report 2018: Executive Summary. Paris, UNESC (IOC Brochure 2020-2)

[7] UNESCO-IOC. 2020.Capacity Assessment of Tsunami Preparedness in the Indian Ocean – Status Report, 2018. Paris, UNESC (IOC Technical Series No. 143)

CAPACITY ASSESSMENT AND GLOBAL CONTEXT

The overall UNESCO-IOC Tsunami Programme contributes to several global frameworks within a Multi-Hazard Early Warning System (MHEWS) context (Figure 5).

Of particular relevance is also the UN initiative launched in 2022 by the UN Secretary-General, Antonio Guterres, “Early Warnings for All” (EW4ALL). This initiative aims to ensure that everyone on Earth is protected from hazardous weather, water, or climate events through life-saving early warning systems by the end of 2027. While tsunami warning and mitigation systems relate to a geophysical hazard, the core warning and mitigation elements within countries are similar and often the responsibility of the same agencies. Improvements to tsunami warning and mitigation systems will therefore contribute to the EW4ALL initiative. The EW4ALL initiative utilises four pillars to undertake a coordinated effort to evaluate the current status of tsunami warning systems and develop roadmaps to address any issues preventing warnings getting to all in the community (see Figure 5).

Figure 5: Related Global Initiatives

In June 2021, UNESCO-IOC launched the Ocean Decade Tsunami Programme (ODTP) [8] [9] as part of the Decade of Ocean Science for Sustainable Development (2021–2030) (https://oceandecade.org/) – an effort to further bolster the global tsunami warning system by greatly enhancing response times and community readiness. Its main objectives are to:

- Enhance systems’ capacity to issue actionable and timely warnings for tsunamis from all identified sources to 100% of coasts at-risk;
- Guarantee that 100% of communities at-risk are prepared and resilient to tsunamis by 2030 through efforts like the UNESCO-IOC Tsunami Ready Recognition Programme (TRRP) [10]

The UNESCO-IOC Tsunami Programme makes significant contributions to the implementation of all the Sustainable Development Goals (SDGs) of the UN 2030 Agenda for Sustainable Development, in particular SDG #11 (Sustainable Cities and Communities) and SDG #14 (Life Below Water).

[8] UNESCO-IOC. 2023. Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme – Executive Summary, UNESCO, Paris. (IOC Brochure 2023-4)
[9] UNESCO-IOC. 2023. Research, Development and Implementation Plan for the Ocean Decade Tsunami Programme. Paris, UNESCO (IOC Technical Series No180)
[10] UNESCO-/IOC. 2022. Standard Guidelines for the Tsunami Ready Recognition Programme. Paris, UNESCO (IOC Manuals and Guides No. 74)

Within the overarching Sendai Framework for Disaster Risk Reduction, the UNESCO-IOC Tsunami Programme supports all targets: Global Target A (Substantially reduce global disaster mortality by 2030); Global Target B (Substantially reduce the number of affected people globally by 2030); Global Target C (Reduce direct economic loss in relation to global domestic product (GDP) by 2030); Global target D (Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030); Global target E (Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020); Global Target F: Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030); and Global target G (Substantially increase the availability of, and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030).

METHODOLOGY

The 2024 Member State Survey was based on the survey undertaken for the 2018 Capacity Assessment of Tsunami Preparedness of Member States of the ICG/IOTWMS, thereby also facilitating a comparison of results between 2018 and 2024. The survey consisted of six main parts. The University of Huddersfield of the United Kingdom again assisted with the preliminary analysis of the survey data, which was reviewed and further developed by the Ad Hoc Team 2024 IOTWMS CATP (Figure 6).

As part of the capacity assessment process, the survey was disseminated by the UNESCO-IOC Secretariat to all ICG/IOMTWS Member States in May 2024. Formally designated Tsunami Nationally Contacts (TNCs) of the ICG/IOTWMS for each Member State coordinated national responses to the survey. The survey was made available through a SurveyMonkey link.

A total of 22 of the current 24 active Member States responded, including: Australia, Bangladesh, Comoros, France Indian Ocean Territories, India, Indonesia, Iran, Kenya, Madagascar, Malaysia, Maldives, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Seychelles, Singapore, South Africa, Sri Lanka, Thailand, United Arab Emirates. Australia, Bangladesh, Comoros, France Indian Ocean Territories, India, Indonesia, Iran, Kenya, Madagascar, Malaysia, Maldives, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Seychelles, Singapore, South Africa, Sri Lanka, Thailand, United Arab Emirates. This is an increase in the response rate from the 2018 survey, when 20 countries completed the survey. However, two countries that completed the 2018 survey did not respond to the 2024 survey (Tanzania and Timor-Leste) and four Member States responded that didn't respond to the 2018 survey. Therefore, the samples aren't exactly same for a full comparison.

The overall assessment was also based on further information on capacity and gaps identified by the work of the ICG/IOTWMS Working Groups and Task Team, and an ongoing assessment of national tsunami warning chains and associated Standard Operating Procedures (SOPs).

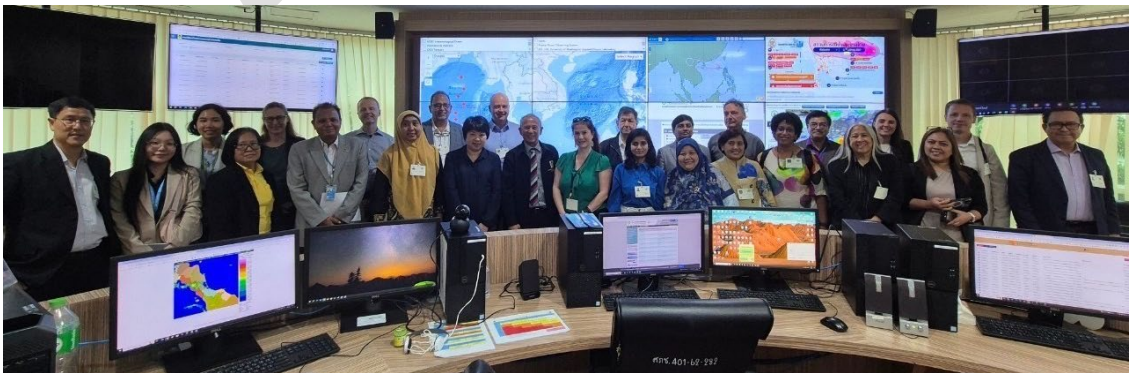


Figure 6: Participants 2024 IOTWMS CATP Validation Workshop, 4-6 September 2024, Bangkok, Thailand.

CAPACITY ASSESSMENT RESULTS

In general, the 2024 survey and analysis of related information shows much progress has been made between 2005 and 2018 to develop reasonably robust and state-of-the-art regional and national tsunami warning systems. However, between 2018 and 2024 progress has somewhat plateaued and slowed, especially with regards to preparedness at the community level. Capacity development is now required to enhance the timeliness and accuracy of the existing warning systems and greatly improve preparedness of at-risk communities. It's also important to note that while some countries may have the capability, they don't necessarily have the capacity/resources to fully implement.

Policies And Plans

Countries were asked in the survey to confirm the availability and type of national tsunami policy they have, including whether it is multi-hazard or standalone, and which components of disaster management it includes, from prevention and mitigation, through to preparedness, emergency response, and rehabilitation and reconstruction (Figure 7).

The survey indicates that 20 (91%) countries have some form of a national tsunami policy. A majority address tsunami as a part of a multi-hazard policy. Over 80% of countries have a national policy that includes an emergency response component and over 75% that addresses the preparedness component. However, less than 60% of countries have a policy that addresses the rehabilitation and reconstruction component. Overall, the results show a reduced level of availability of national policies when compared to the 2018 survey results, but this may mean they need updating.

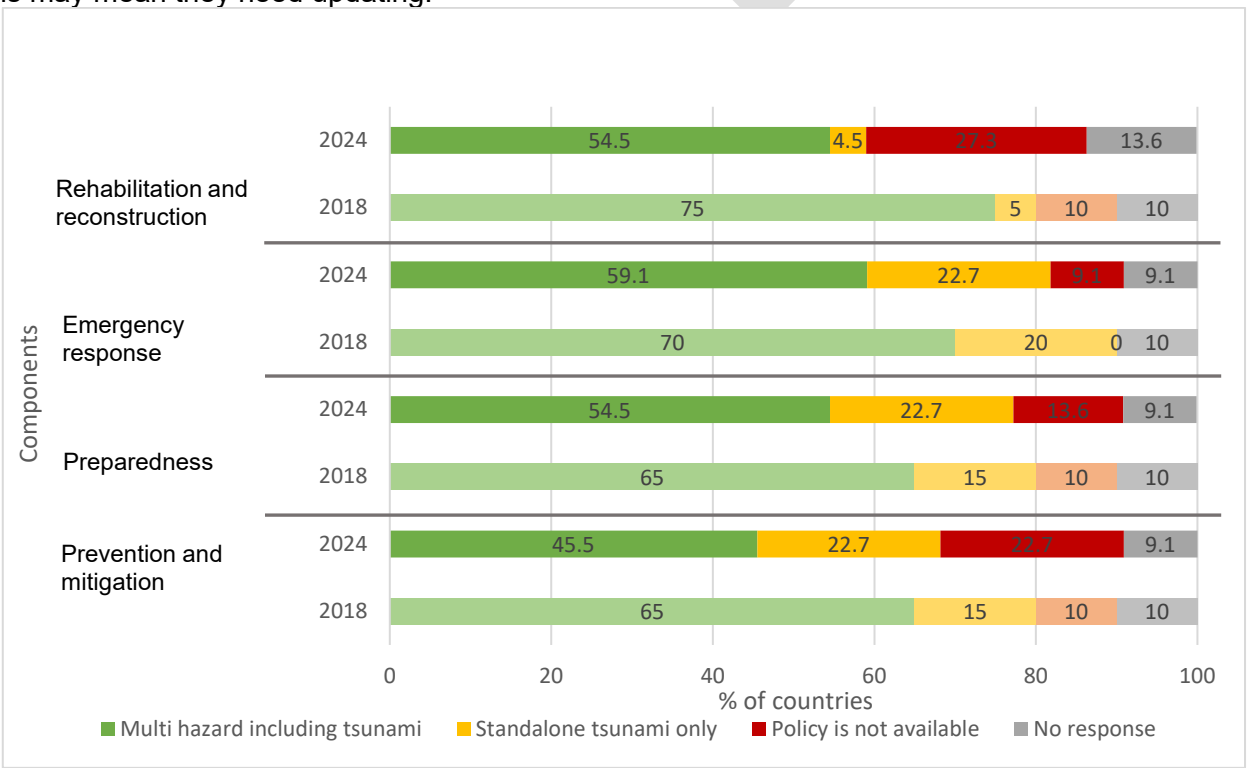


Figure 7: Types and components of national tsunami policy

14 (64%) countries have some form of local tsunami policy (Figure 8). A majority of those address tsunami as a part of a multi-hazard policy. Over 60% of countries have a policy with emergency response and preparedness components, and over 50% have a policy that includes prevention and mitigation & rehabilitation and reconstruction components. Overall, the survey results show a similar level of availability of local policies when compared to the 2018 survey results.

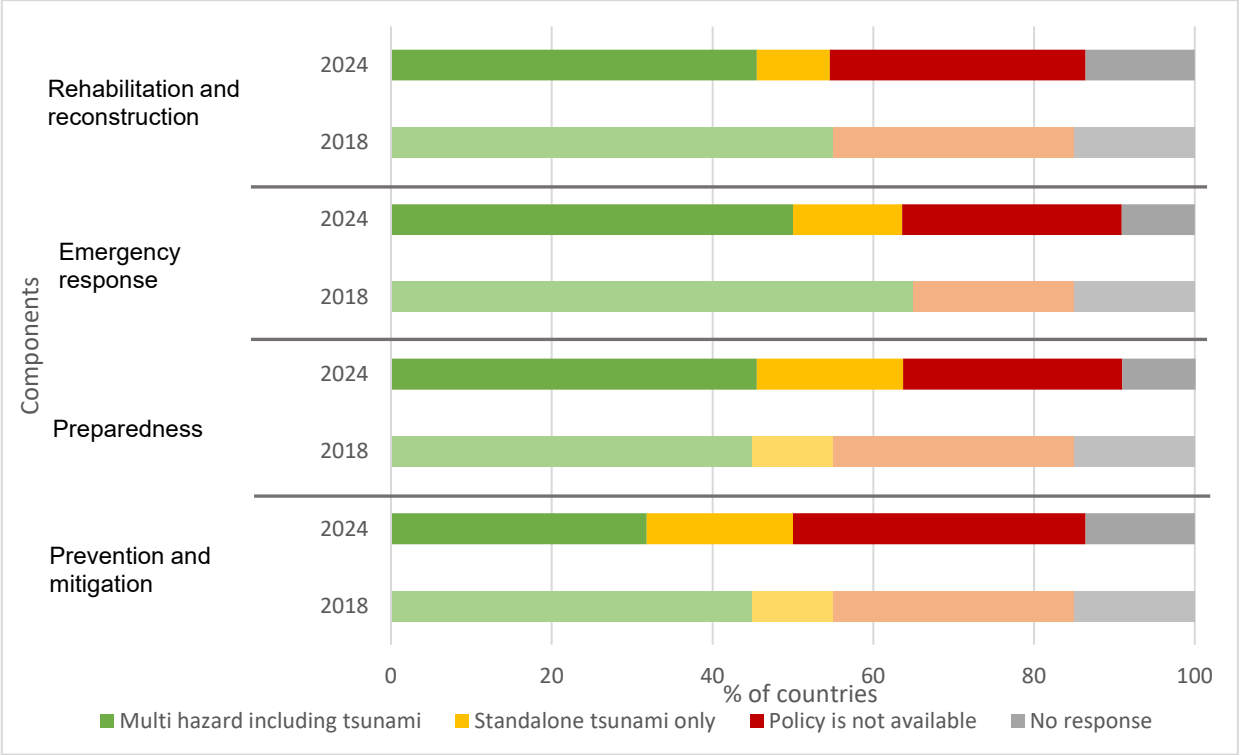


Figure 8: Types and components of local tsunami policy

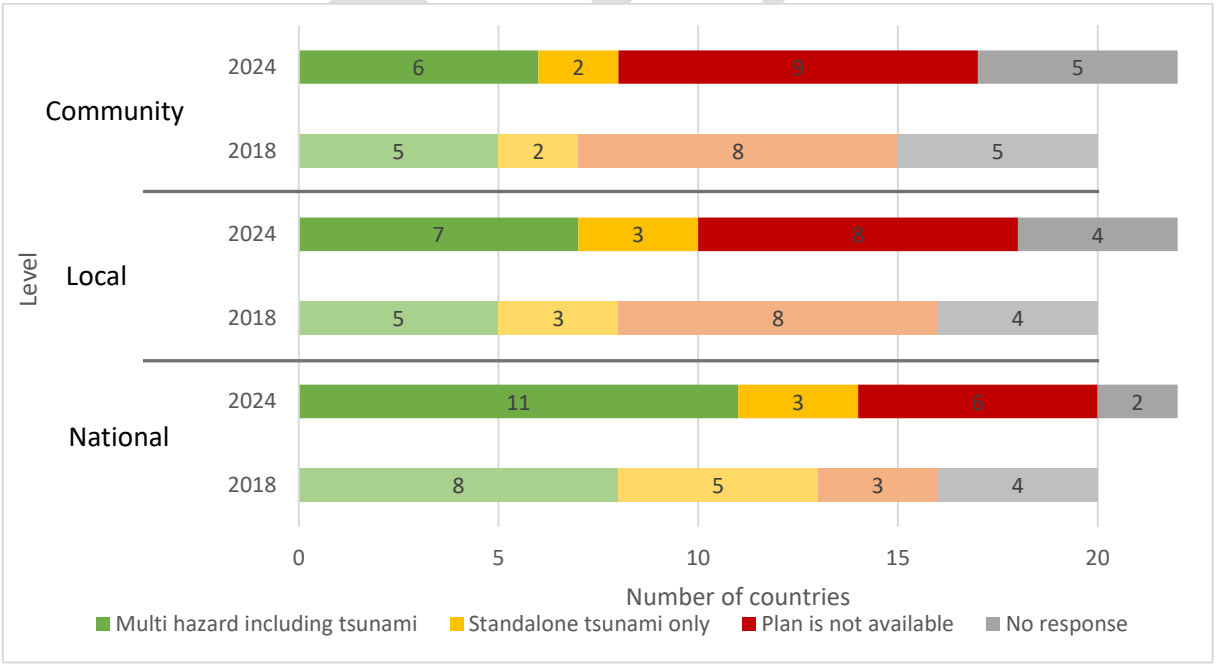


Figure 9: Availability of national, local and community level tsunami disaster risk reduction plans for prevention and mitigation component

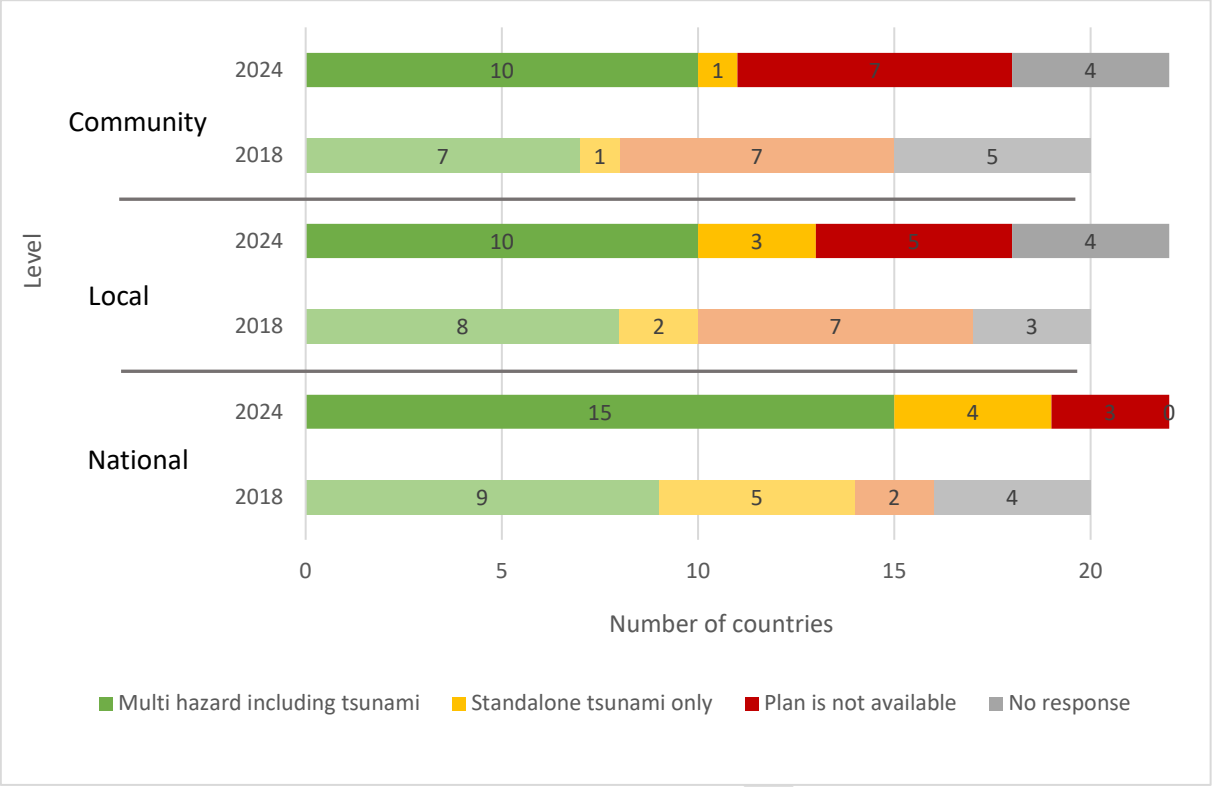


Figure 10: Availability of national, local and community level tsunami disaster risk reduction plans for preparedness component

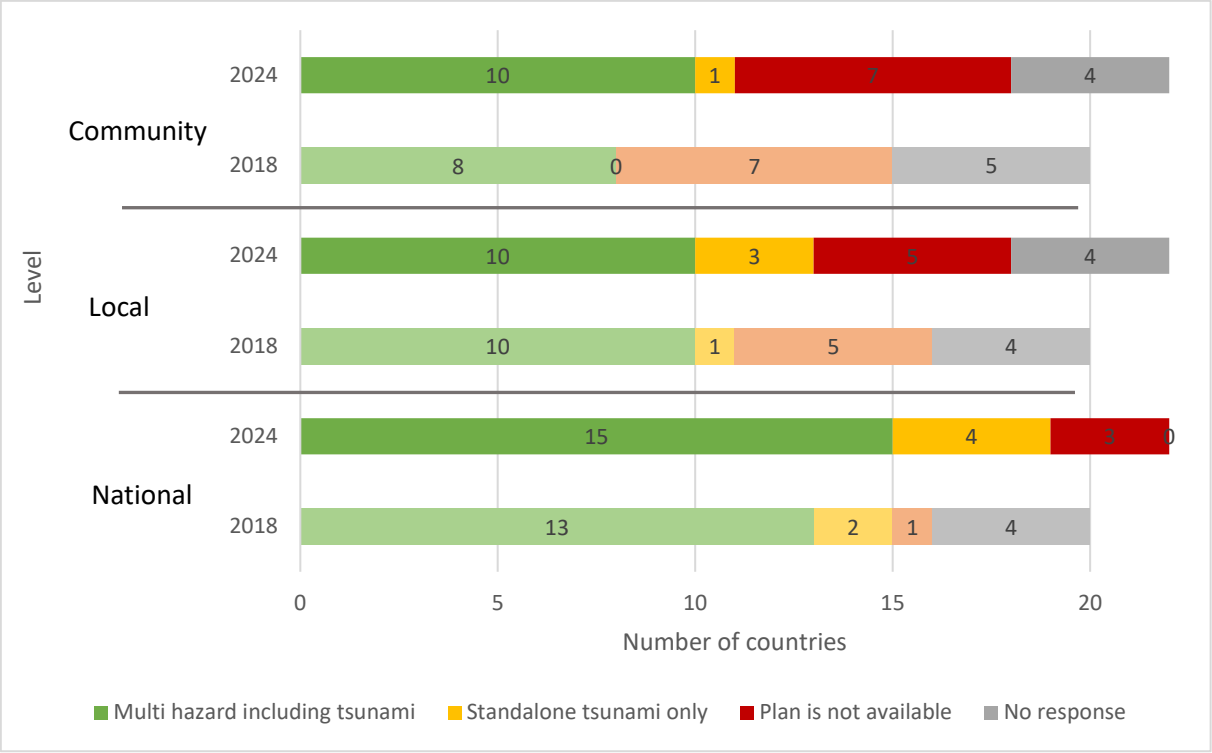


Figure 11: Availability of national, local and community level tsunami disaster risk reduction plans for emergency response component

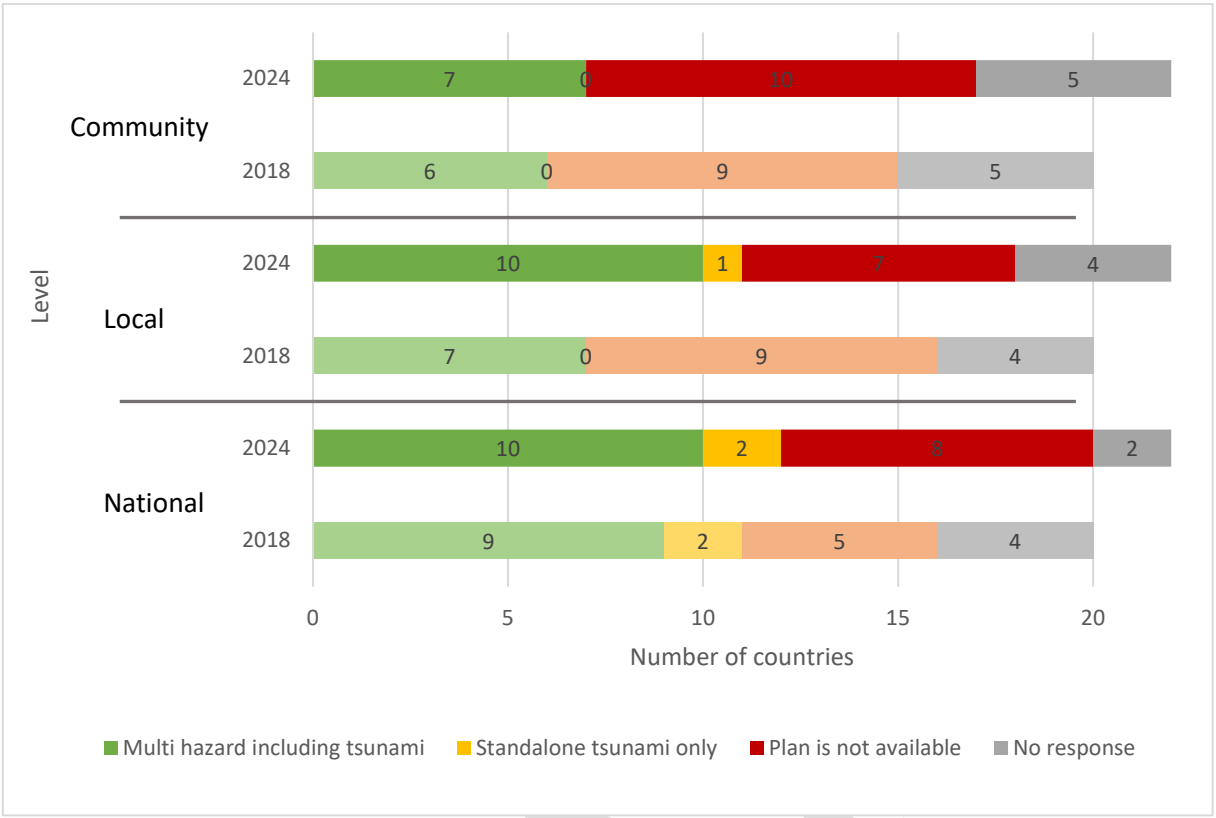


Figure 12: Availability of national, local and community level tsunami disaster risk reduction plans during rehabilitation and reconstruction phase

Countries were asked to confirm the availability, level and type of tsunami risk reduction plans they have, including whether it is multi-hazard or standalone, whether it is at the national, local or community level, and which components of disaster management it includes, from prevention and mitigation (Figure 9), through to preparedness (Figure 10), emergency response (Figure 11), and rehabilitation and reconstruction components (Figure 12).

All 22 (100%) countries have some form of tsunami disaster risk reduction plan. A significant majority of countries address tsunami risk reduction as a part of a multi-hazard plan, rather than as standalone plans. There is least availability at the community level.

Across all four components of disaster management, availability of plans is significantly higher at the nationallevel, followed by the local level. There is least availability at the community level. For example, at the emergency response component 86% of countries have national level plans, while 59% have local and 50% have community level plans. This pattern is similar in all components of disaster management.

Availability of tsunami plans is highest during the preparedness and emergency phases. For example, the 86% of countries with national plans at the emergency response phase exceeds those during the prevention and mitigation component (64%) and the rehabilitation and reconstruction component (55%). This pattern is replicated at the local and community levels, with availability at the emergency response and preparedness components exceeding other components.

19 (86%) countries reported that their tsunami disaster risk reduction plans are based on hazard and/or risk assessments.

Countries were asked to confirm the availability and type of national tsunami guidelines they have, including whether it is multi-hazard or standalone, and which components of disaster management are included, from prevention and mitigation, through to preparedness, emergency response, and rehabilitation and reconstruction (Figure 13).

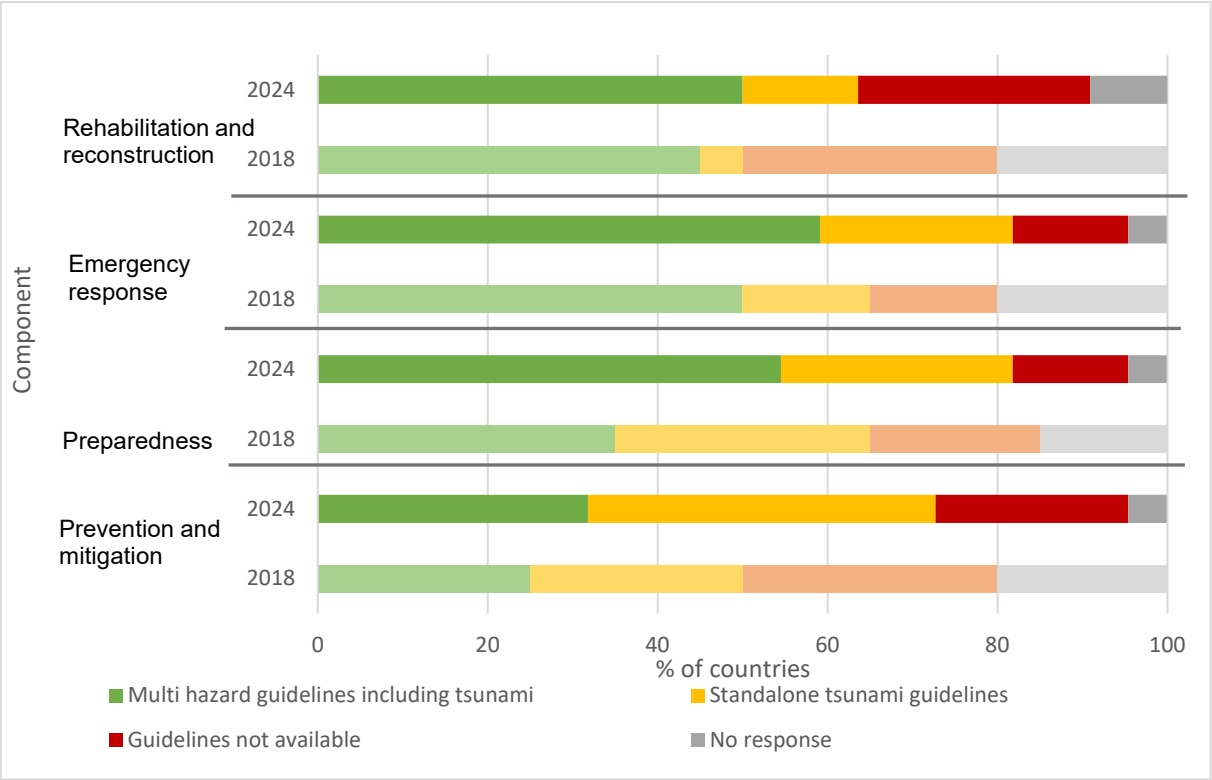


Figure 13: Types and components of national tsunami guidelines

All 22 (100%) countries have some form of national tsunami guidelines. For the prevention and mitigation component there is a mix of standalone guidelines and those that address tsunami as a part of a multi-hazard guideline. for the other components, they predominantly address tsunami as a part of national multi-hazard guidelines. The results show that a majority of countries (>60%) have national tsunami guidelines that address all components. However, there is least availability in the rehabilitation and reconstruction component. Overall, there is an increased availability of national tsunami guidelines in all components, compared to the 2018 survey results.

Using the same approach, countries were asked to confirm the availability and type of local tsunami guidelines they have, including whether it is multi-hazard or standalone, and which components of disaster management are included, from prevention and mitigation, through to preparedness, emergency response, and rehabilitation and reconstruction (Figure 14).

17 (77%) countries have some form of local tsunami guidelines. Across the disaster management components, the majority address tsunami as a part of multi-hazard guidelines. 11 (50%) countries have local tsunami guidelines that address the preparedness component. They are not as commonly found in other components, including emergency response (41%), prevention and mitigation (46%), and rehabilitation and reconstruction (36%).

After major improvements in 2018 since 2005, overall progress has mainly plateaued since 2018, except for a major increase in national guidelines (Figure 15). While capacity remains in general high at the national level, capacity development is still required at the local level for policies, plans and guidelines for around 40% of countries. Policies and plans should continue to be included as part of a multi-hazard approach.

Figure 14: Types and components of local tsunami guidelines

Figure 15: Summary country activity and capacity status for policies and plans.

Hazard and Risk Assessment

Awareness is the first step in the development of any warning and mitigation system. Hazard and risk assessments for tsunamis generated by subduction earthquakes continue to be updated and integrated within multi-hazard frameworks to provide awareness to governments, response authorities, and the community on any possible threat. This facilitates the development of appropriate preparedness. All countries around the Indian Ocean are at some level of risk of being impacted by tsunamis. Even relatively small tsunamis of 1m in amplitude can create dangerous currents and possible inundation of areas close to the foreshore, leading to loss of life and impacts on livelihoods, such as ports, fishing and tourist industries.

Hazard and risk assessments for tsunamis generated by subduction earthquakes continue to be updated and over 75% integrated within multi-hazard frameworks to provide awareness to governments, response authorities, and the community on any possible threat. The UNESCAP funded project "Strengthening Early Tsunami Warning in the NW Indian Ocean through Regional Collaboration" has further examined the seismic characteristics and prepared a Probabilistic Tsunami Hazard Assessment (PTHA) for the region. The PTHA now needs to be extpanded to the rest of the Indian Ocean.

From the survey results, 21 (96%) countries conduct hazard assessments of some kind to understand the hazard threats to their territory. This compares to all 20 (100%) countries that responded in 2018. The Seychelles, which did not respond to the 2018 survey, was the only country not to carry out a tsunami hazard assessment in 2024.

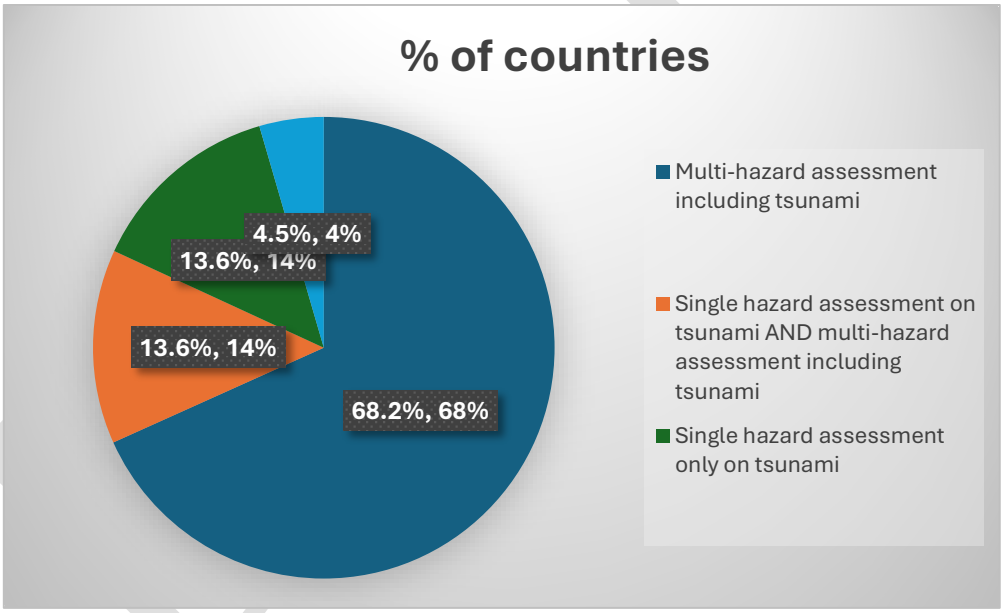


Figure 16: Type of hazard assessment

Figure 16 shows the type of hazard assessment carried out by those countries. 15 (68%) countries reported conducting a multi-hazard assessment that includes tsunami, three (14%) countries a single hazard assessment on tsunami and a multi-hazard assessment including tsunami, and three (14%) countries a single hazard assessment on tsunami only.

For those countries that carry out multi-hazard assessments, respondents were then asked to identify the type(s) of hazard included in the assessment.

Figure 17 shows the number of hazards included in the multi-hazard assessments conducted by each country. Out of the 19 countries that conducted a multi-hazard assessment, one country included seven, and

seven countries included six hazards from Tsunami, Cyclone, Drought, Earthquakes, Epidemics, Flooding, Landslide, and Volcanic eruptions. Three countries included five hazards, and four countries included four hazards.

While 21(100%) countries include tsunami in their hazard assessment, 15 (68%) countries who do multi-hazard assessments also include flooding, 14 (64%) include cyclones, and 13 (59%) include earthquakes (Figure 18). Less common hazards to be included are drought and landslides for 10 (46%) countries, epidemics for 6 (27%) countries, and volcanic eruptions for four (18%) countries.

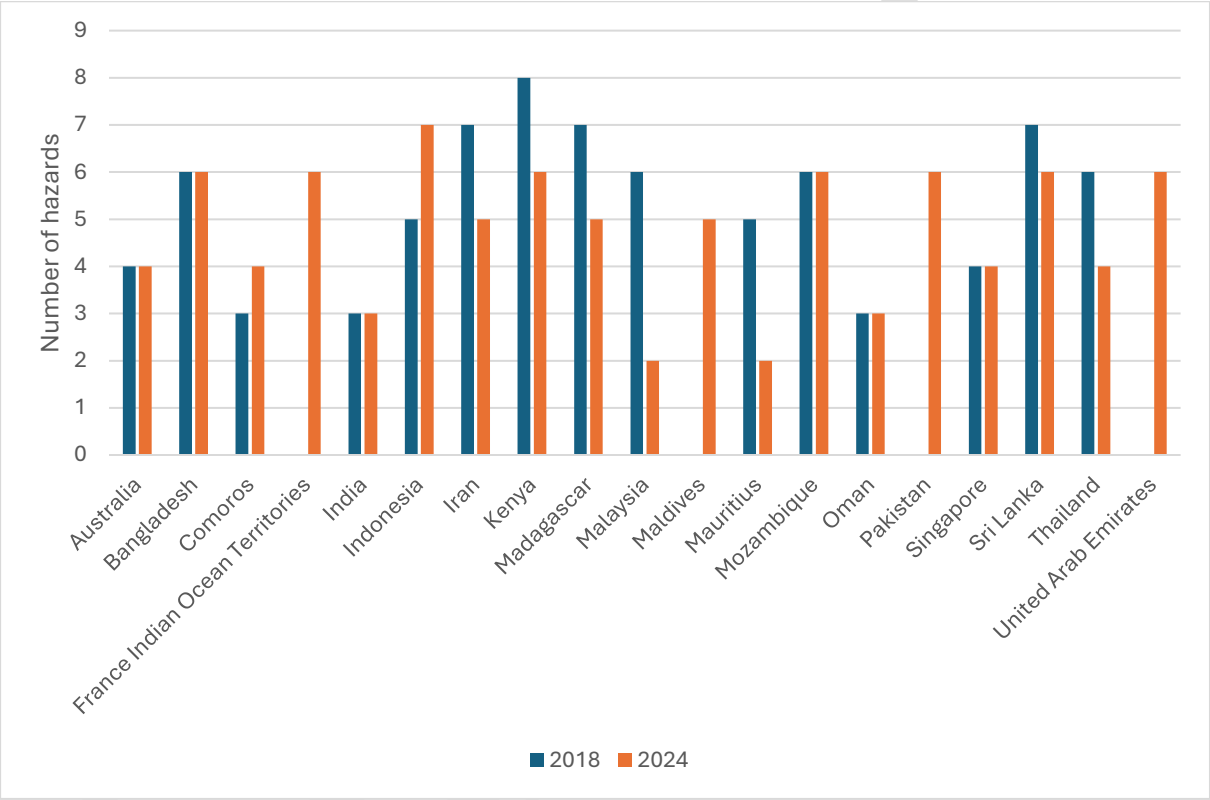


Figure 17: Number of hazards included in multi-hazard assessments

Countries were then asked to identify which organisation(s) is/are responsible for the tsunami hazard assessment and at what level they are carried out. When tsunami hazard assessments were carried out by countries, 15 (68%) countries involve a national agency, seven (32%) a national or local university, five (23%) a national or international consultant, and eight (36%) an international agency (Figure 19). Nine (41%) countries doing tsunami hazard assessments involve multiple types of organisation.

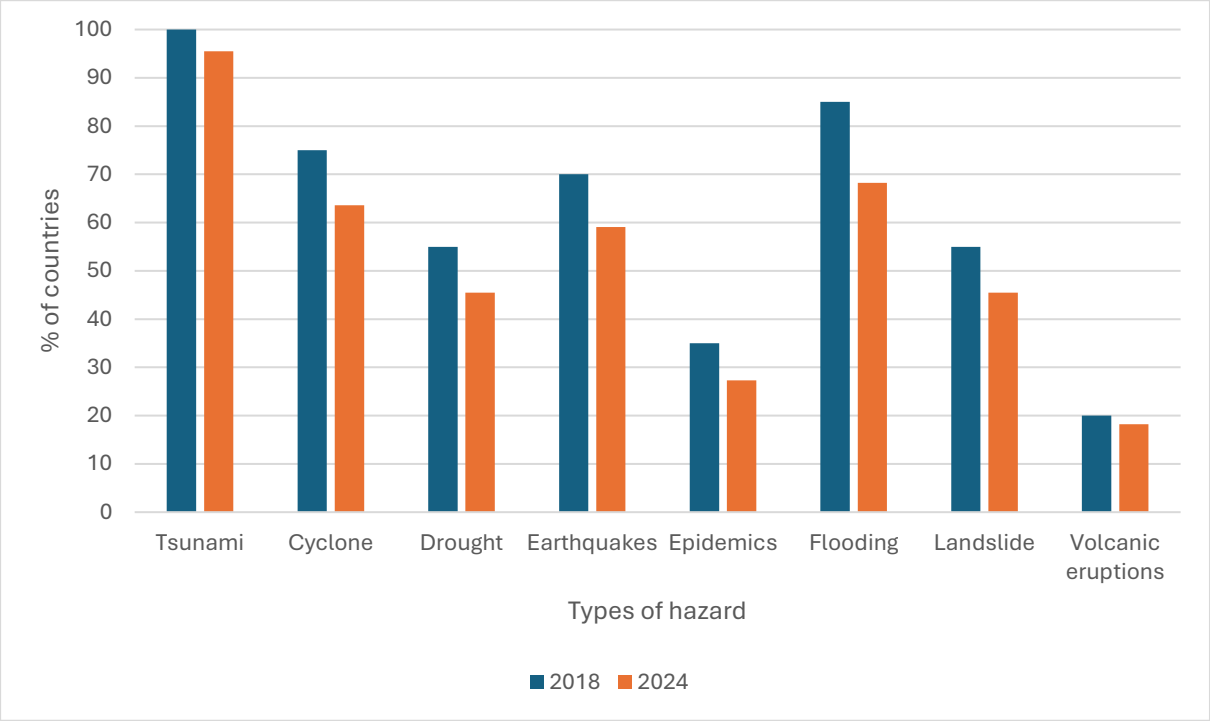


Figure 18: Type of hazard(s) included in multi-hazard assessment

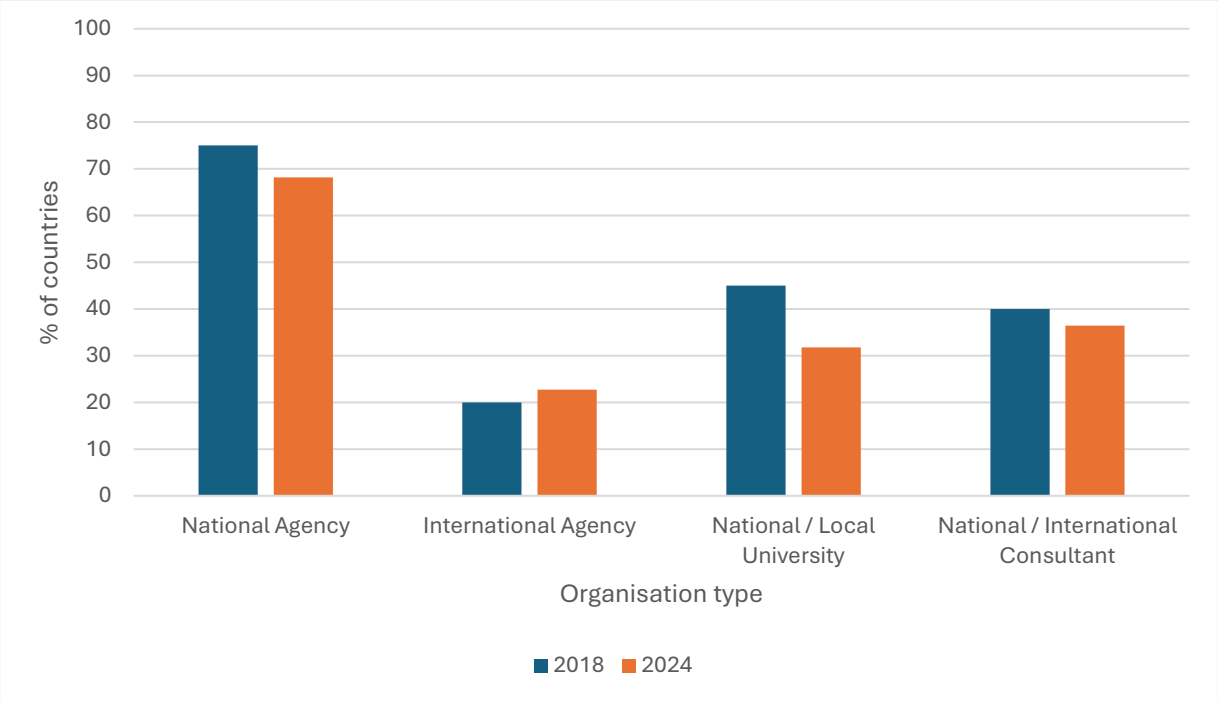


Figure 19: Organisation(s) responsible for the tsunami hazard assessment

13 (59%) countries carry out the tsunami hazard assessment at a national level, 10 (45%) countries at the regional level, 10 (45%) at the city level, and six (27%) at the village level (Figure 20). 11 (50%) countries carry out hazard assessments at multiple levels.

Countries were then asked to identify the type of data used to support their tsunami hazard assessment and whether that data is publicly available. 16 (73%) countries identified two or more data types used to support their tsunami hazard assessment. Bathymetry and topography data are the most widely used (Figure 21). 50% or more of the countries also use seismo-tectonic models, infrastructure details and/or land cover data. However, none of the data sources are widely available to the public (only in <40% of countries).

The number and type of products to emerge from the tsunami hazard assessment varies greatly across the 22 respondent countries. The most common products (Figure 22) are inundation maps (77%), hazard maps (59%) and evacuation maps (50%). The other products are developed by less than 50% of countries. One country, Thailand, produces all seven products, while a majority of countries produce three products or less (Figure 23).

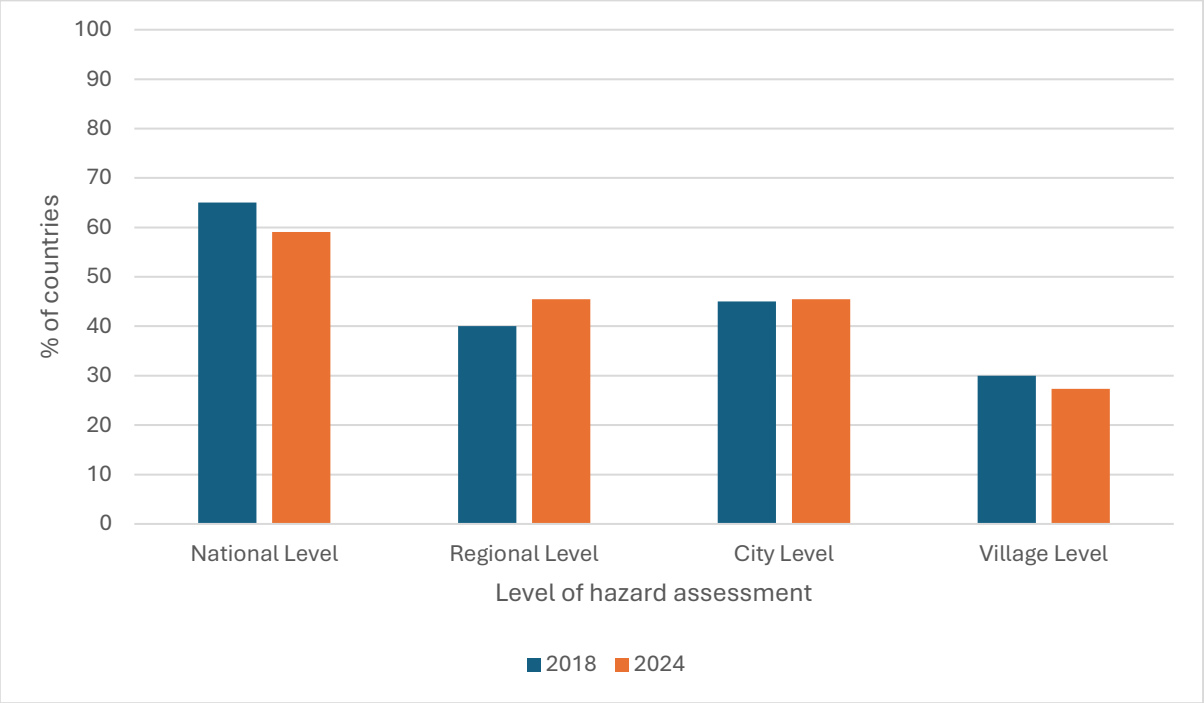


Figure 20: Level of tsunami hazard assessment when carried out

Figure 21: Data types used for tsunami hazard assessment

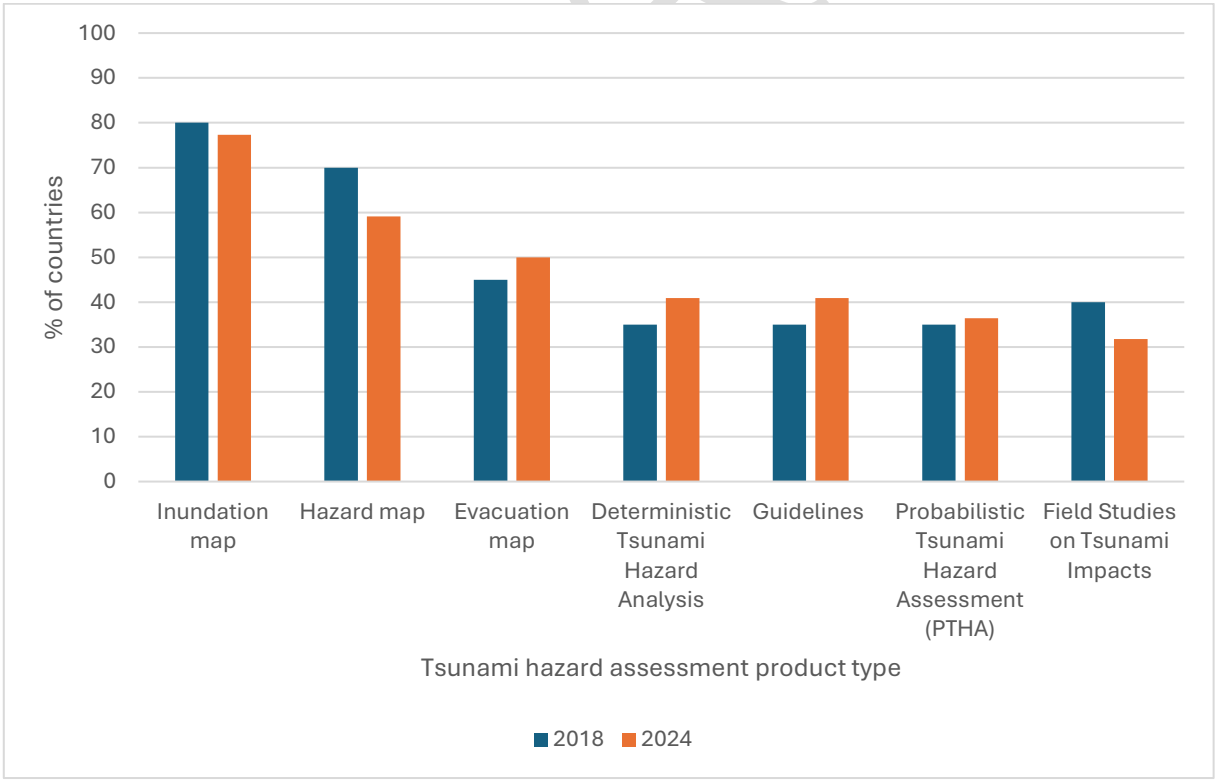


Figure 22: Products from tsunami hazard assessment

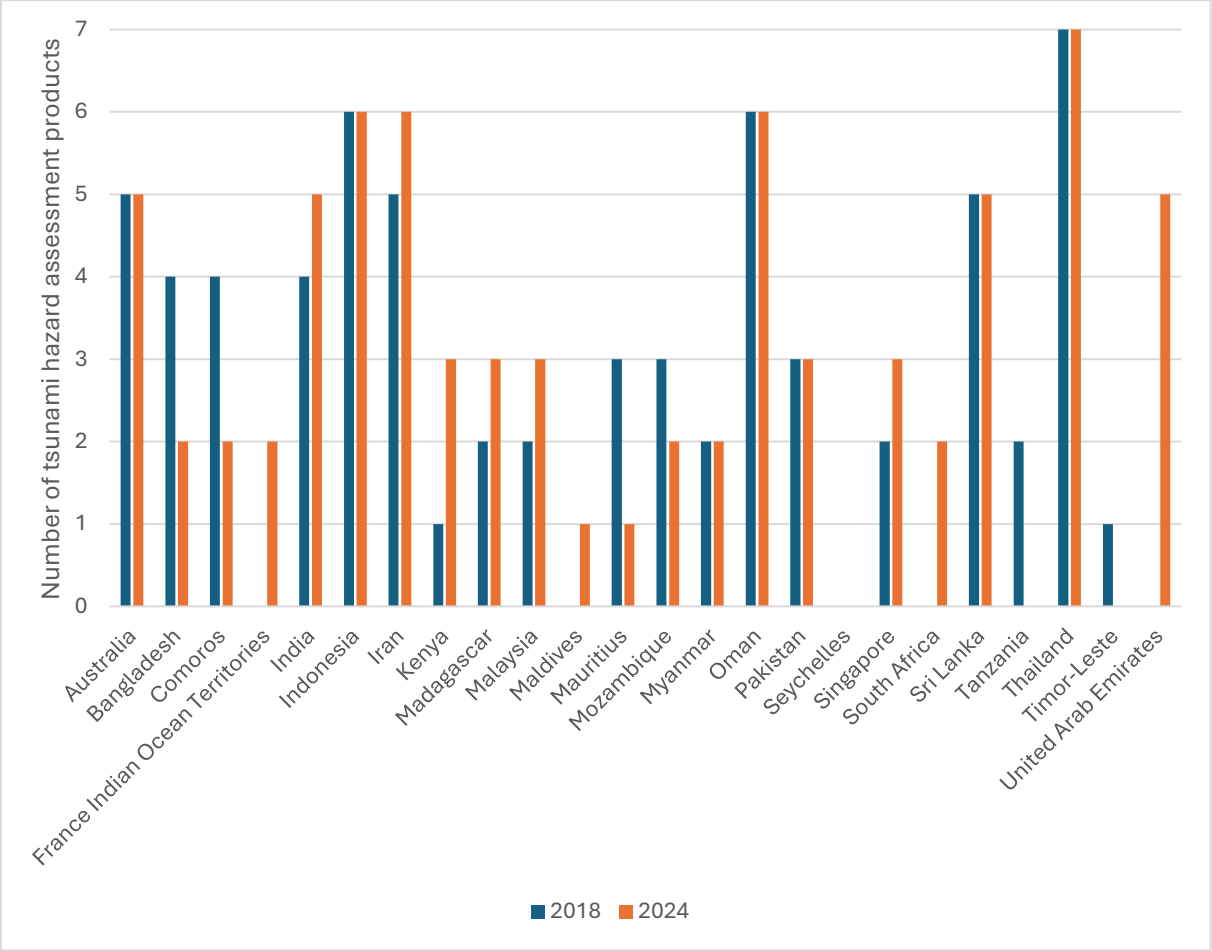
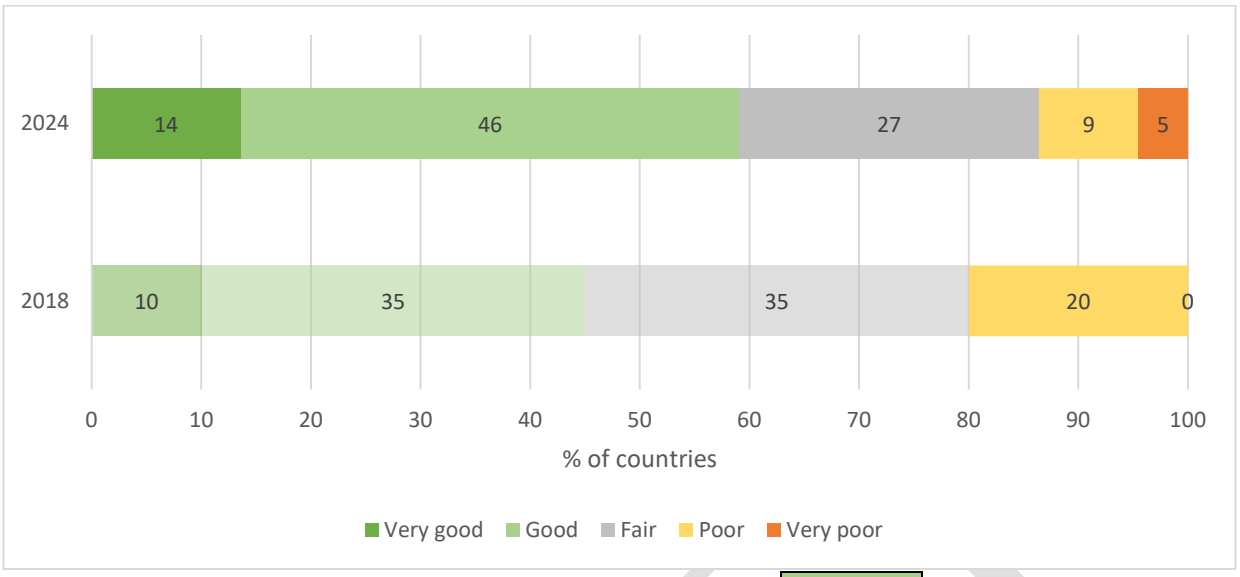


Figure 23: Number of tsunami hazard assessment products

Countries were then asked to rate their capacity to undertake tsunami hazard assessment. There is a wide-ranging capacity, with 13 (59%) countries rating themselves as having very good or good, while six (27%) countries rate themselves as having fair capacity. Three (14%) countries rated themselves as having poor or very poor capacity (Figure 24).

In a similar manner, each respondent was then asked to rate their country's priorities for capacity improvement across six areas of tsunami hazard assessment, using a five-point scale, from not a priority to essential. The responses indicate that all areas require capacity improvement in at least some countries, but using a weighted response across the twenty two respondent countries[11], evacuation mapping was ranked as the highest priority for capacity improvement, followed by hazard mapping and inundation mapping, followed by deterministic tsunami hazard analysis and then Probabilistic Tsunami Hazard Assessment (PTHA) (Table 2). For comparison, the ranking for the 2018 survey results is indicated in brackets.

Countries were also asked to rate their capacity to give training and/or consultancy to other countries on the same six aspects of tsunami hazard assessment, using a five-point scale, from no capacity to very good capacity (Figure 25). The results indicate that there is capacity among the respondent countries to deliver training and/or consultancy in all six areas of tsunami hazard assessment. It is highest for inundation mapping (>40% of countries) and lowest for PTHA and field studies on tsunami impacts (<30% of countries).



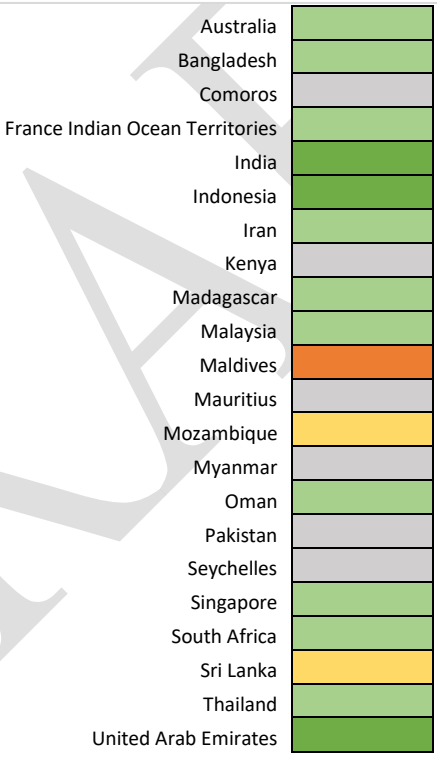


Figure 24: Capacity to undertake tsunami hazard assessments

Table 2: Ranking of priority areas for capacity improvement in tsunami hazard assessment

Areas of tsunami hazard assessment	RII	2024 Rank (2018 Rank)
Evacuation map	0.85	1 (1)
Hazard map	0.81	2 (2)
Inundation map	0.81	2 (3)
Deterministic tsunami hazard analysis	0.76	4 (4)
Probabilistic tsunami hazard assessment (PTHA)	0.75	5 (6)
Field studies on tsunami impacts	0.67	6 (5)

Countries were then asked to consider the extent and nature of tsunami risk assessments carried out. 19 (86%) countries participating in this survey conduct tsunami risk assessments. 12 (55%) countries report conducting a multi-hazard risk assessment that includes tsunami, five (23%) countries a single hazard assessment on tsunami and a multi-hazard assessment including tsunami, and two (9%) countries a single hazard assessment on tsunami only (Figure 26).

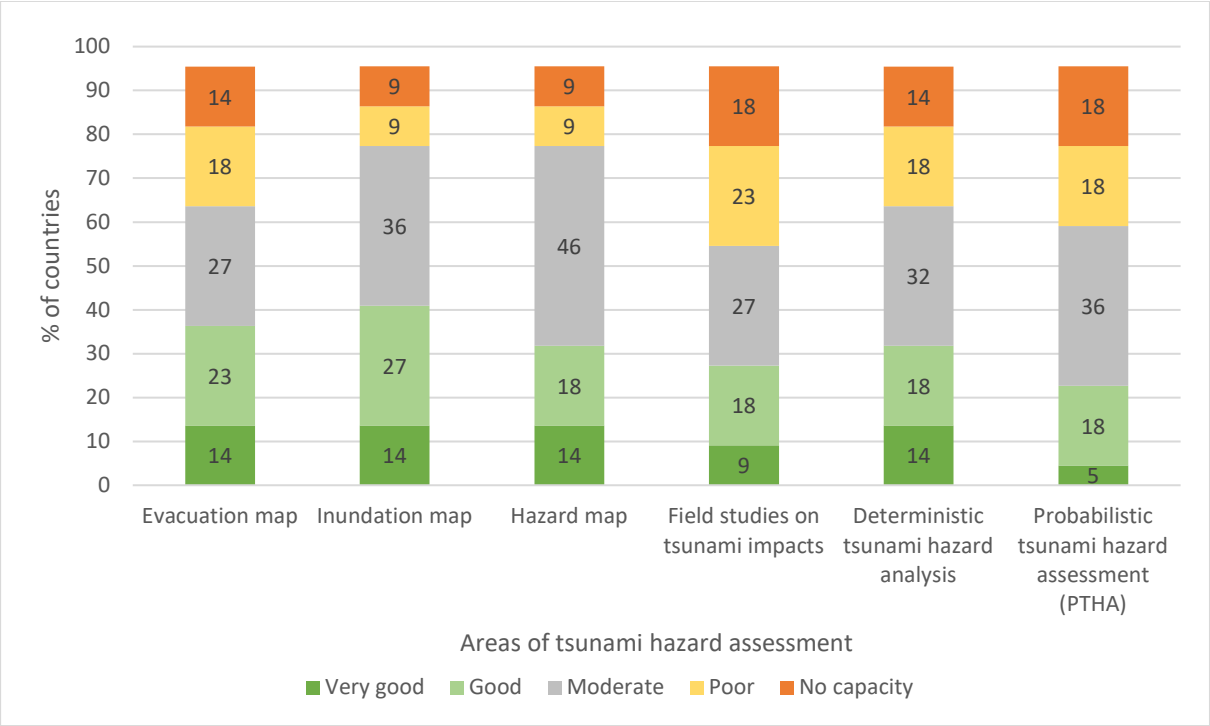
All 17 countries that carry out multi-hazard risk assessments include tsunami, while flooding, cyclones and earthquakes considered by 60% or more of countries (Figure 27).

Countries were asked to identify the organisation(s) that is/are responsible for carrying out risk assessments and the level at which they are carried out. The organisation(s) responsible for carrying out tsunami risk assessments vary across the respondent countries (Figure 28). However, in 68% of countries a national agency is fully or partially responsible. Other organisations include an international agency, national or local university or international consultant, although each in less than 20% countries. In six countries (27%), the tsunami risk assessment is the responsibility of multiple actors.

Of the countries that carry out tsunami risk assessments, 11 conduct them at the national level, and eight at a regional and or city level (Figure 29). Village (seven) and/or community (four) level assessments are less common, but there is a significant increase in reporting of them when compared with the 2018 results. Nine countries carry out risk assessment at multiple levels.

The number and type of products developed from the tsunami risk assessment varies across the respondent countries (Figure 30). A risk map is produced by 17 of the countries (77% of all countries) that conduct tsunami risk assessments. 50% or more countries also produce evacuation maps and/or guidelines from the risk assessments, a significant increase from that reported in 2018. Action plans remain a less common output, with just 32% countries producing them. 15 countries develop two products or more.

Each country was also asked to rate their capacity to undertake tsunami risk assessments using a five-point scale, from very poor to very good. The responses indicate wide ranging capacity across the 22 respondent countries (Figure 31). Over 85% of countries rates their capacity as fair or better, with over 40% of countries rating their capacity as very good or good. This is a significant improvement when compared to the 2018 survey results. However, three countries (14%) still rate themselves as having poor or very poor capacity.



	Evacuation map	Inundation map	Hazard map	Field studies on tsunami impacts	Deterministic tsunami hazard analysis	Probabilistic tsunami hazard assessment
Australia						
Bangladesh						
Comoros						
France Indian Ocean Territories						
India						
Indonesia						
Iran						
Kenya	NR	NR	NR	NR	NR	NR
Madagascar						
Malaysia						
Maldives						
Mauritius						
Mozambique						
Myanmar						
Oman						
Pakistan						
Seychelles						
Singapore						
South Africa						
Sri Lanka						
Thailand						
United Arab Emirates						

Figure 25: Capacity to give training and/or consultancy on tsunami hazard assessment to other countries

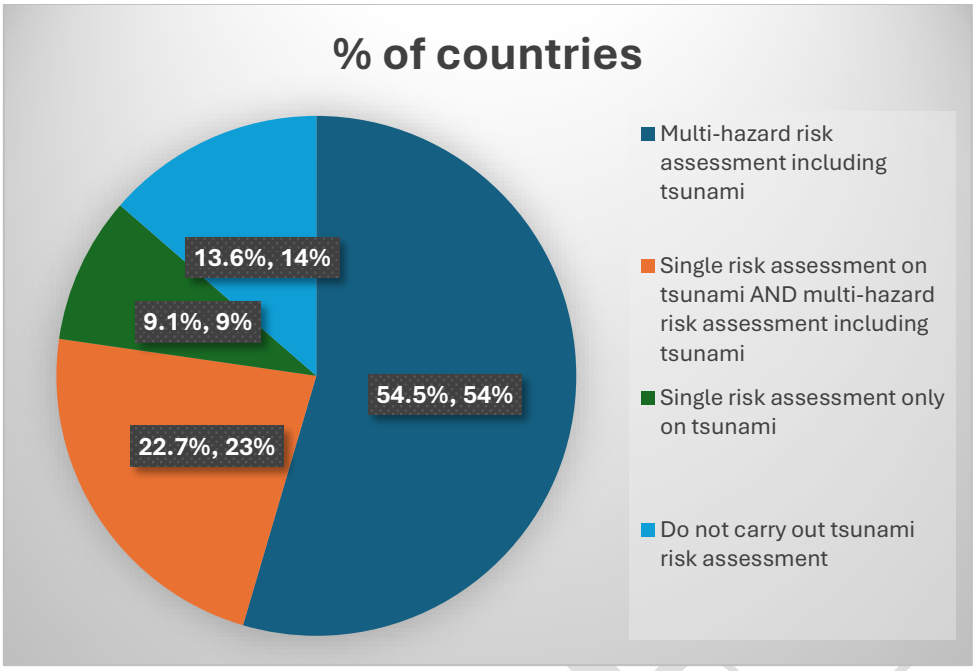


Figure 26: Types of risk assessment

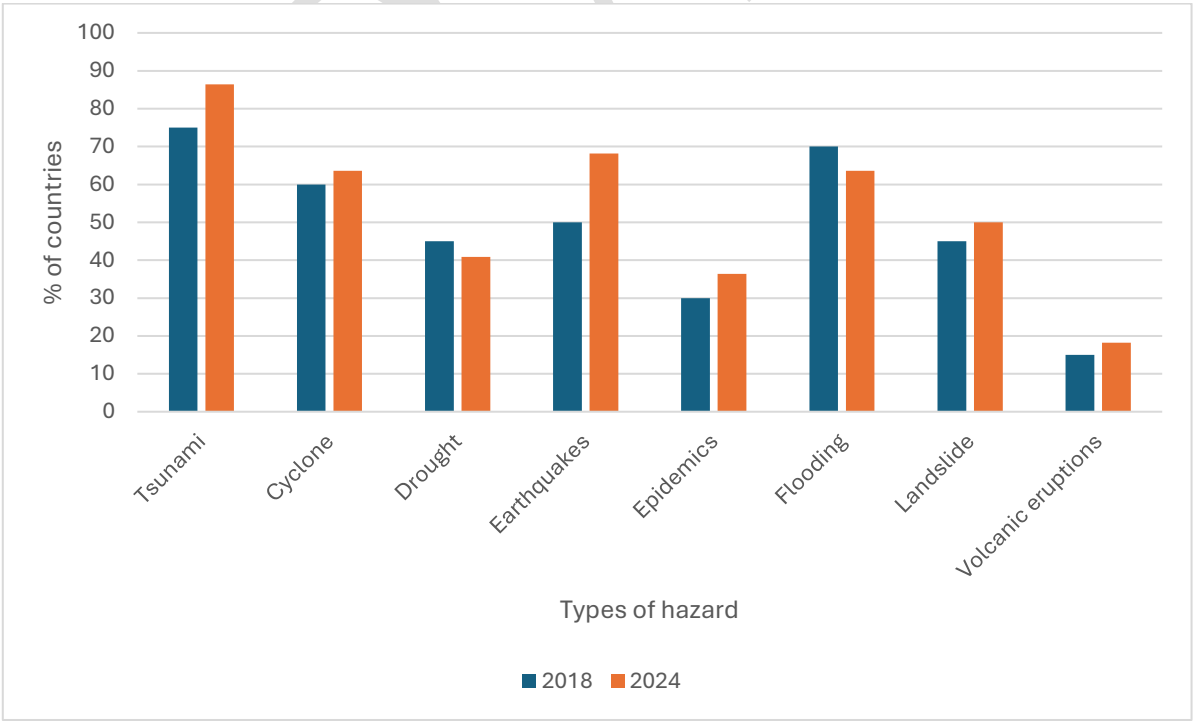


Figure 27: Type of hazard included in the multi-hazard risk assessment

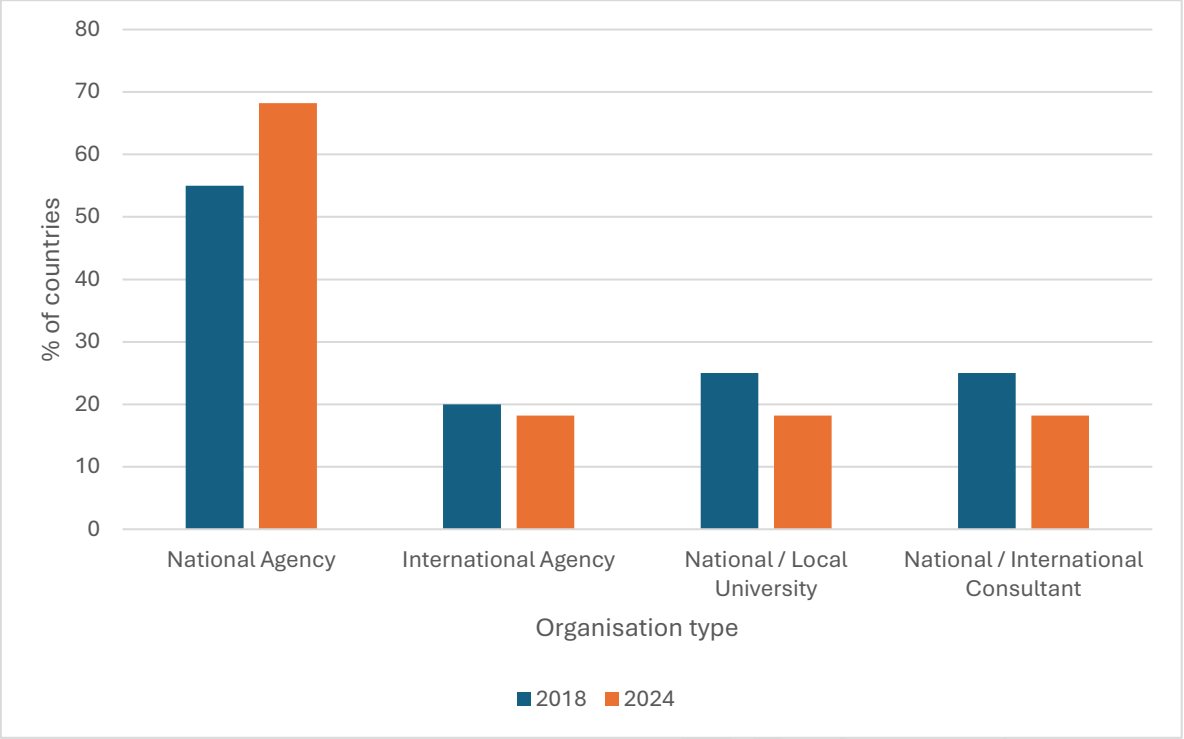


Figure 28: Organisation(s) responsible for the tsunami risk assessment

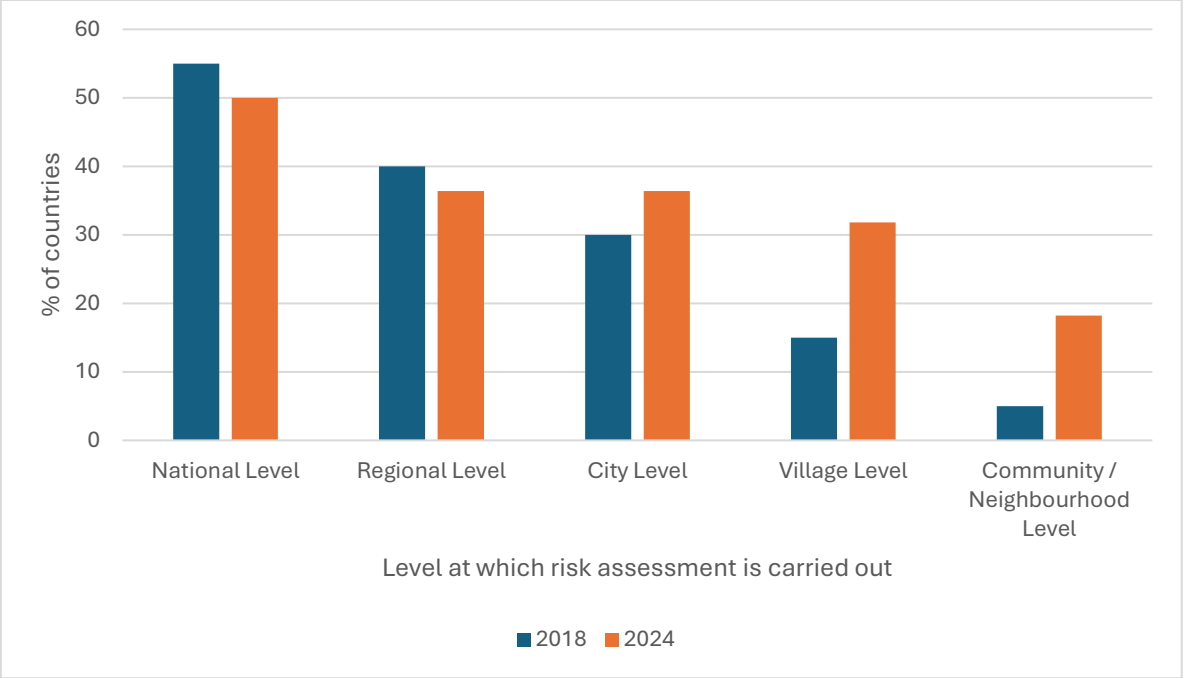


Figure 29: Levels at which the tsunami risk assessment when carried out

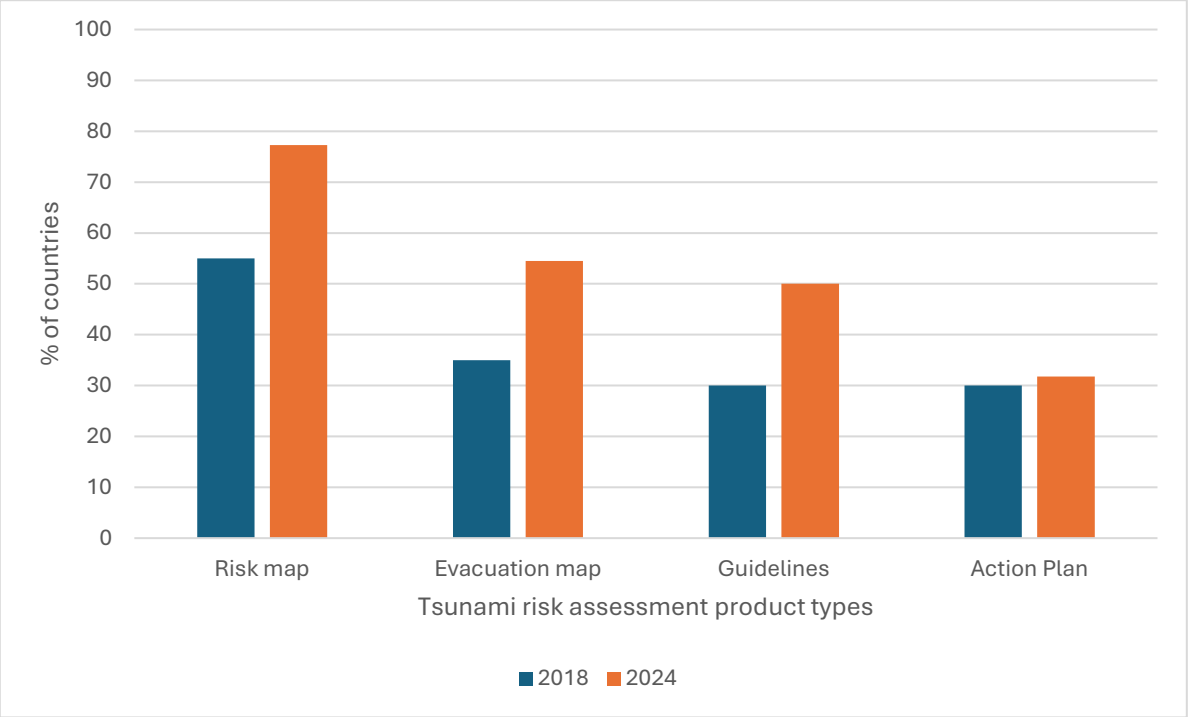


Figure 30: Type of product to emerge from the tsunami risk assessment

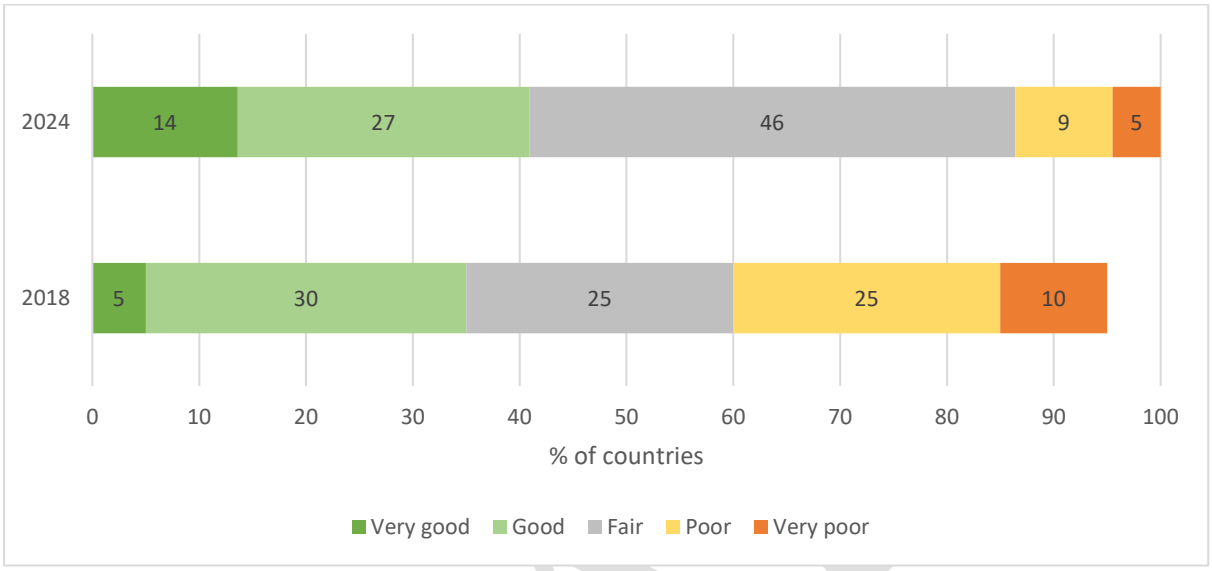
Table 3: Priorities for capacity improvement in tsunami risk assessment

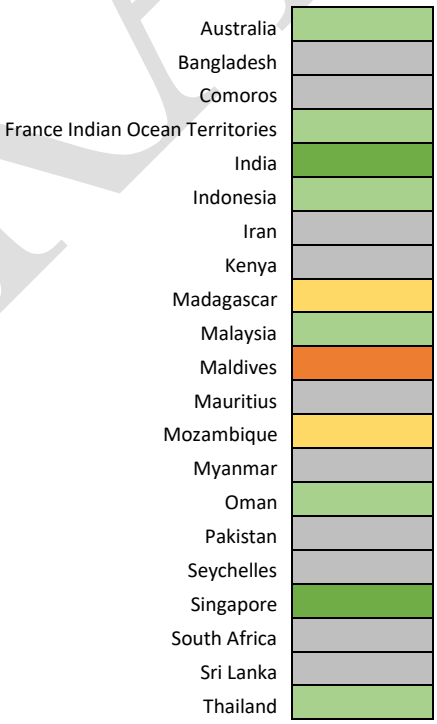
Priority level	RII	2024 Rank (2018 Rank)
Tsunami risk assessment at city level	0.82	1 (1)
Tsunami risk assessment at national level	0.79	2 (4)
Tsunami risk assessment at regional level	0.78	3 (5)
Tsunami risk assessment at village level	0.75	4 (2)
Tsunami risk assessment at community / neighbourhood level	0.74	5 (3)

Using a similar approach to hazard assessment, each country was then asked to rate their priorities for capacity improvement across five levels of tsunami risk assessment, using a five-point scale, from not a priority to essential. The responses indicate that all areas require capacity improvement in at least some countries (rated as essential priorities), but using a weighted response across the twenty respondent

countries[12], city level risk assessment is ranked as the highest priority for capacity improvement, followed by national and regional levels (Table 3).

Each country was also asked to rate their capacity to give training and/or consultancy to other countries on the same five levels of tsunami hazard assessment (community to national), using a five-point scale, from no capacity to very good capacity (Figure 32). The results suggest that for each level of risk assessment, 50% or more countries have at least moderate capacity to give training and/or consultancy to other countries, with several countries also reporting good or very good capacity at each level.





[12] $RII = \frac{\Sigma W}{AxN}\ (0 \leq R \leq 1)$

Where W is the weightage given to each factor, A is the highest weight, and N is the number of respondents

United Arab Emirates

Figure 31: Capacity to undertake tsunami risk assessment

	National	Regional	City	Village	Community / neighbourhood
Australia					
Bangladesh					
Comoros					
France Indian Ocean Territories					
India					
Indonesia					
Iran					
Kenya					
Madagascar					
Malaysia					
Maldives					
Mauritius					
Mozambique			NR		
Myanmar					
Oman					
Pakistan					
Seychelles					
Singapore					
South Africa					
Sri Lanka					

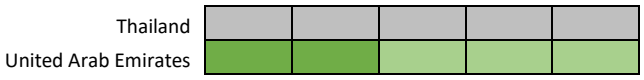


Figure 32: Capacity to give training on tsunami risk assessment

Once again it can be seen that after significant improvements between 2005 and 2018, progress has mainly plateaued since 2018 (Figure 33). There currently remains a wide-ranging capacity to undertake detailed tsunami hazard assessments, with 13 (59%) countries rating themselves as having very good or good, while six (27%) countries rate themselves as having fair capacity. Three (14%) countries rated themselves as having low or very low capacity. The highest priorities for capacity improvement requested by the countries were hazard mapping and inundation mapping, followed by deterministic tsunami hazard analysis and then PTHA.

There is also a wide-ranging capacity to undertake detailed risk assessments (Figure 9). Over 85% of countries rates their capacity as fair or better, with nine (40%) countries rating their capacity as very good or good. This is a significant improvement when compared to the 2018 survey results. However, three countries (14%) still rate themselves as having low or very low capacity and require capacity development.

More effort is required to make the data more publicly available, to provide hazard and risk assessments at the village/community level and for tsunamis generated by non-seismic and complex sources. More measures of uncertainty associated with all assessments will better inform risk-based decisions

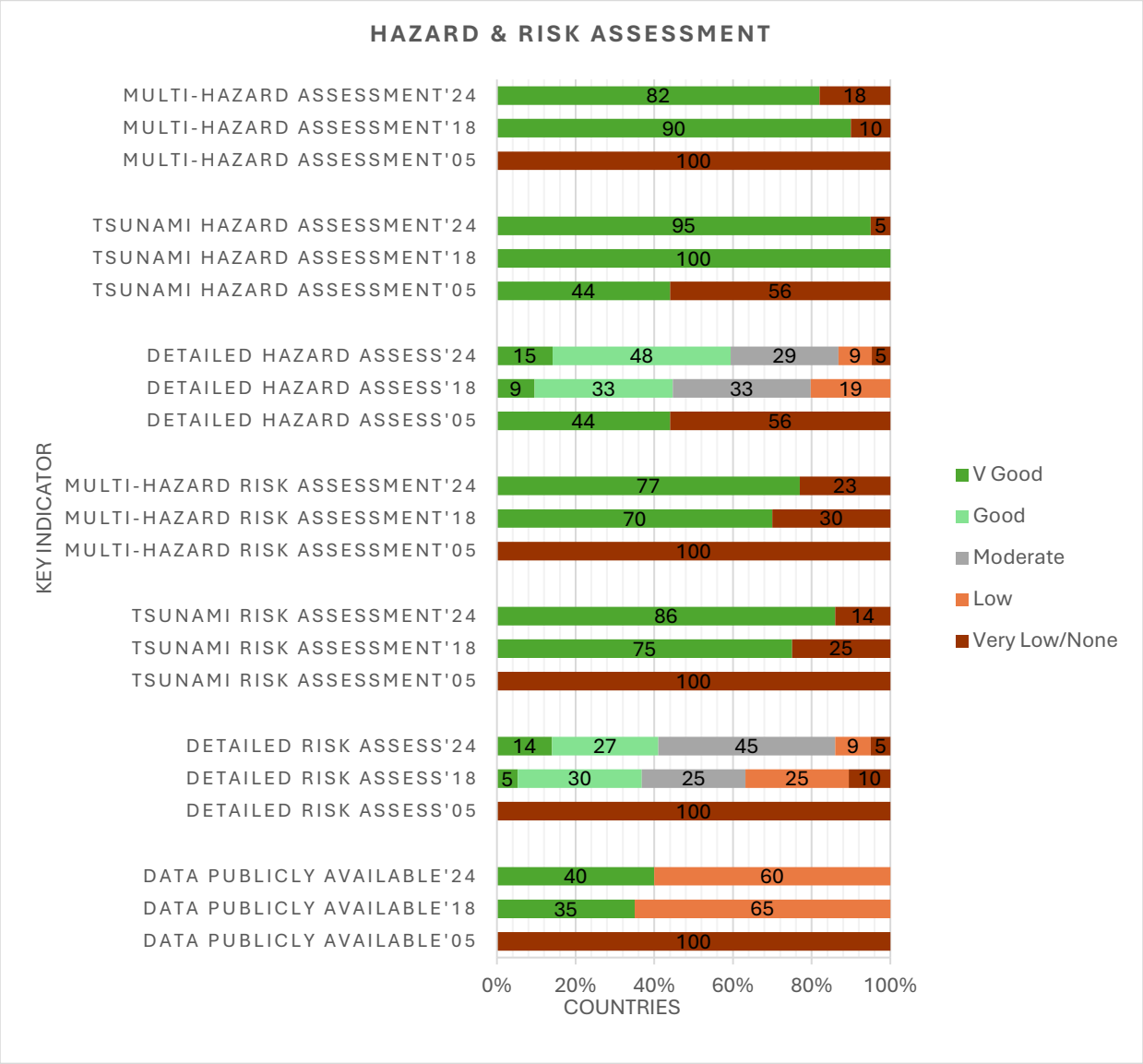


Figure 33: Summary country activity and capacity status for hazard and risk assessment.

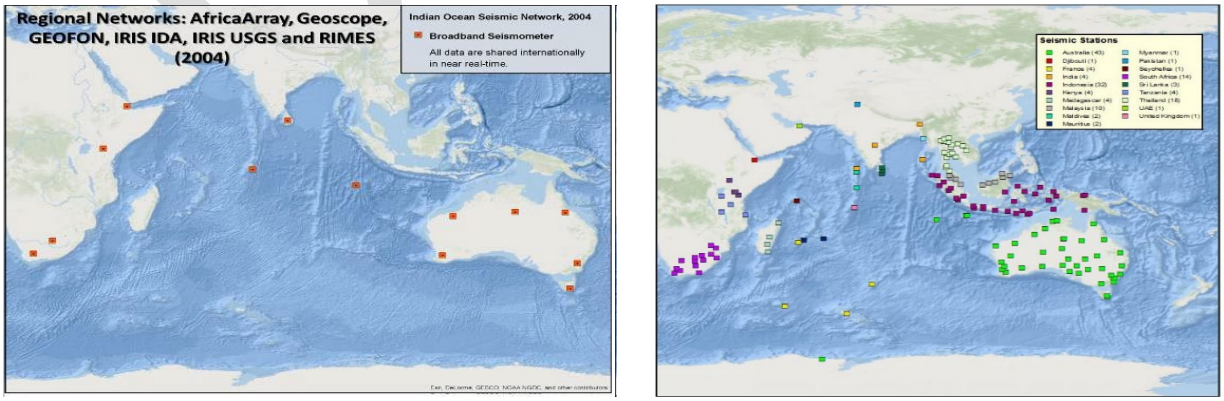
Detection, Warning, and Dissemination

A coordinated network of seismometers across the Indian Ocean provides real-time information for the detection of potentially tsunami generating earthquakes. A coordinated network of sea-level monitoring systems (tide gauges and deep ocean tsunameters) provides real-time information to confirm whether a tsunami has been generated. Using this information and modelled forecasts, currently Tsunami Service Providers (TSPs: operated by Australia, India, Indonesia) designated by the ICG for the IOTWMS provide the National Tsunami Warning Centres (NTWCs) in each country with interoperable (same format) tsunami threat information for tsunamis generated by subduction zone earthquakes for the entire Indian Ocean (Figure 34). The performance of the TSPs is measured against Key Performance Indicators agreed by the ICG. Training on the TSP products and their use are provided to countries every two years. Countries select which TSP (or a number of TSPs) they use the tsunami threat information from. One TSP (Australia) is now also providing regional threat information products for tsunamis generated by non-seismic and complex sources, such as volcanoes. Two countries (Indonesia and France) have developed national warning systems for local tsunamis generated by volcanoes

Figure 34: UNESCO-IOC Tsunami Services Providers (Australia, India, Indonesia) provide detailed tsunami threat information to all countries around the Indian Ocean

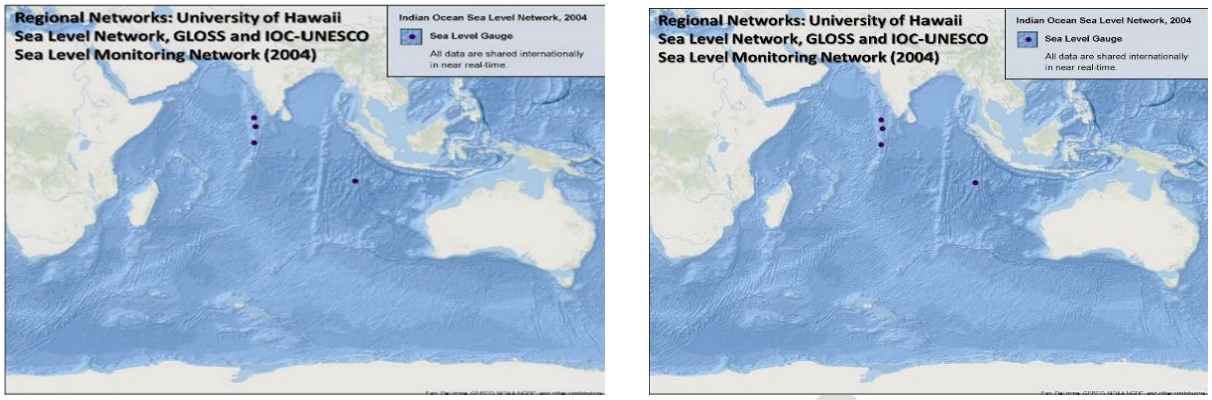
Countries were asked about their access to national or international seismic networks, and access to national or international sea level networks required for detection and confirmation of tsunamis.

20 (91%) countries reported that the responsible organisation has access to national or international seismic networks, with 19 (86%) having access to both national and international networks. 11 (50%) countries reported having access to Global Navigation Satellite System/Global Positioning System (GNSS/GPS) data. 13 (59%) countries reported that the list of broadband seismometers operated by their country is listed accurately in the IOTWMS seismic database:
http://www.ioc-tsunami.org/index.php?option=com_oe&task=viewDocumentRecord&docID=20796
Seven (32%) countries reported that seismic stations had been added to their network when compared to the database listing, while one reported that some stations have been decommissioned. This database therefore needs an update.



(a) **(b)**

Figure 35: Comparison of seismic observations available to TSPs in a) 2004 and b) 2023



(b) **(b)**

Figure 36: Comparison of sea level observations available to TSPs in a) 2004 and b) 2023

15 (68%) countries reported that they have access to national or international sea level networks, with most of those having access to both national and international. 15 (68%) countries reported that the list of sea level stations operated by their country is listed accurately in the IOTWMS sea level database: http://www.ioc-tsunami.org/index.php?option=com_oe&task=viewDocumentRecord&docID=20833 One country reported that stations had been added to their network when compared to the database listing, while two reported that some stations have been decommissioned. This database therefore also "needs an update.

There has been considerable expansion of seismic and sea level observations available for tsunami detection since 2004 (Figures 35 and 36)). However, currently only nine (41%) countries reported that all national seismic data is shared in real-time, while only ten (46%) countries reported that some national seismic data is shared in real-time. Only Eight (36%) countries share all their national sea level data in real-time, while only four (18%) countries share some sea level data in real-time. The relatively low level of data exchange in real-time potentially compromises the accuracy of the detection data and consequentially any tsunami warnings.

Countries were also asked about other observing networks operated by them and used for tsunami early warning (Figure 37). 12 (55%) countries reported that they operated no other observing networks, and one country did not provide a response. Four (18%) countries reported operating GNSS/GPS, and three (14%) reported operating coastal radars. Three (14%) identified other observing networks they operate, including wave and coastal radar, monitoring networks for volcano activity.

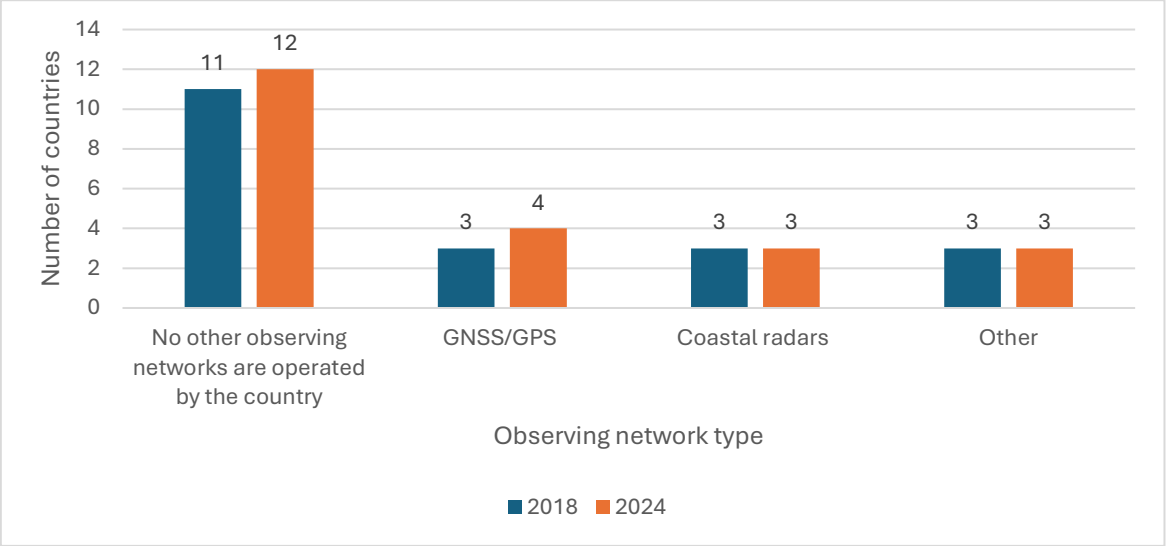


Figure 37: Other observing networks operated and used for tsunami early warning

reach the UN Ocean Decade Tsunami Programme goal to greatly enhance the timeliness and accuracy of warnings to save more lives, for tsunamis generated by not only subduction earthquakes, but also by non-seismic and complex sources, requires more seismic and sea level observations. Not only accessibility to all existing observations in real-time, but also implementation of an expanded network of observations, including the use of new technologies. Only 9 (41%) countries currently building that capacity and much more is required.

All 22 (100%) countries reported that they have a national capability to assess and/or receive potential tsunami threat information and advise / warn their coastal communities (Figure 38). This capacity has successfully remained constant since 2018, and of course a major improvement since 2005. Nine (41%) countries rely solely on the information provided by the UNESCO-IOC ICG/IOTWMS designated IOTWMS Tsunami Service Providers (TSPs), while 12 (55%) countries use TSP data and their own threat assessment data. One country (Australia) relies solely on its own threat assessment data.

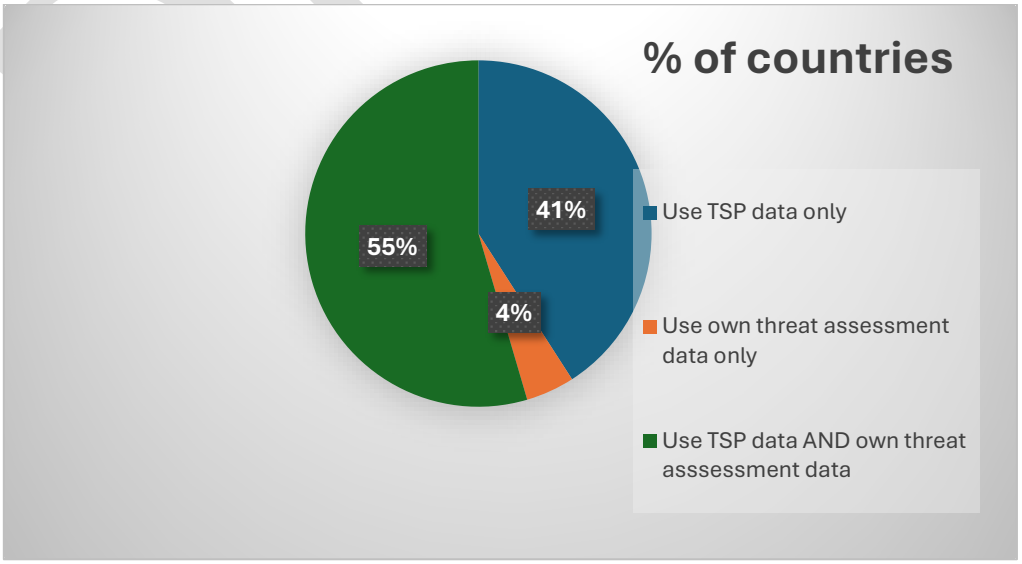


Figure 38: Sources of tsunami threat assessment used to generate national tsunami warnings

18 (82%) countries reported producing national level threat forecast information, while 16 (73%) countries produce local level information (Figure 39). Six (30%) countries reported producing ocean-wide information. 16 (73%) countries reported producing multiple levels of tsunami threat forecast information.

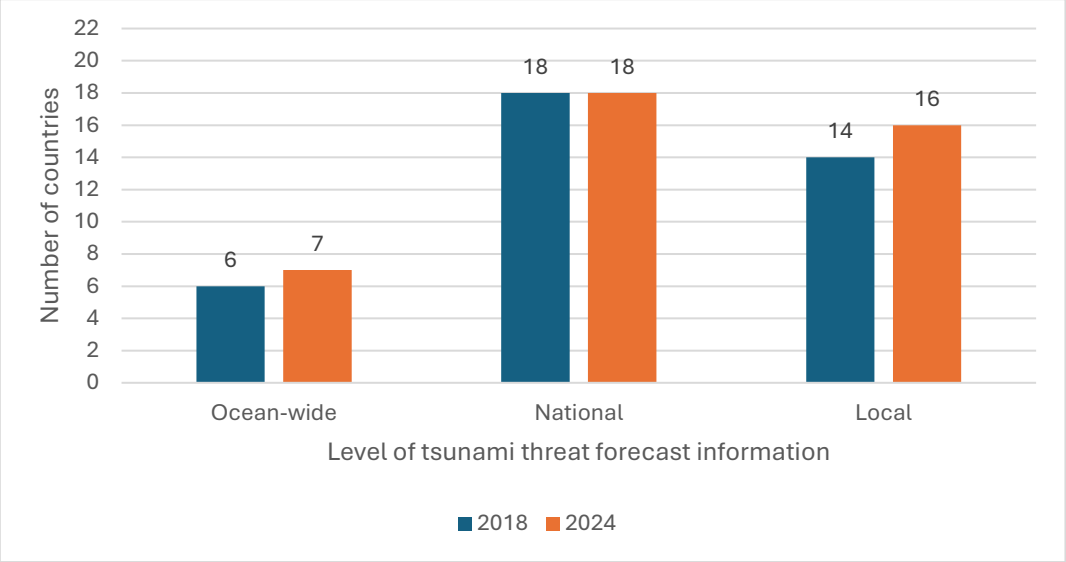


Figure 39: Level of tsunami threat forecast information produced by the responsible organisation

17 (77%) of the respondent countries reported that the organisation responsible for identifying a potential tsunami threat also issues national tsunami watches, advisories, alerts and/or warnings. 20 (91%) countries reported that the organisation responsible for assessing and/or receiving potential tsunami threat information operates 24x7. Comoros and Iran reported operating weekdays and daytime due to a lack of resources, which is a major concern, especially as one country is at higher-risk with a near-field threat.

Countries were asked to report on their capacity to analyse real-time seismic and sea level data for tsunami threat, their capacity for tsunami modelling to support generation of threat forecasts, as well as the software tools they use to support these. Only 12 (55%) countries reported having the capability of analysing real-time seismic and sea-level data for potential tsunami threat. Only 10 (46%) countries also reported having the capability for tsunami modelling to support generation of threat forecasts. A range of software tools are used across the countries. Examples include: SeisComP, TOAST, MOST, COMIT, SIGMA, Tide Tool, TTT, WINITB, ArcGIS, MATLAB, and in-house developed applications. Capacity development is required, although not essential as detailed threat information is available from the TSPs.

Countries were also asked to confirm what type of infrastructure is available to enable 24x7 operations (Figure 40). Computers and the internet were reported by 100% of respondents, while mobile phones or cell phones were reported by 21 (96%) countries. Landline, GTS and UPS were also widely reported (75%+). Fax is also available in a majority of countries, while Satellite phones and VSAT were reported by 32% of respondents or less.

In summary with regards to tsunami detection and warning, significant progress was made between 2005 and 2018 to develop a robust and then state-of-the-art regional tsunami threat information system and associated national tsunami warning systems (Figure 41). However, between 2018 and 2024 progress has again somewhat plateaued. Greater access to real-time data remains an issue and an expansion of existing and new networks is also required.

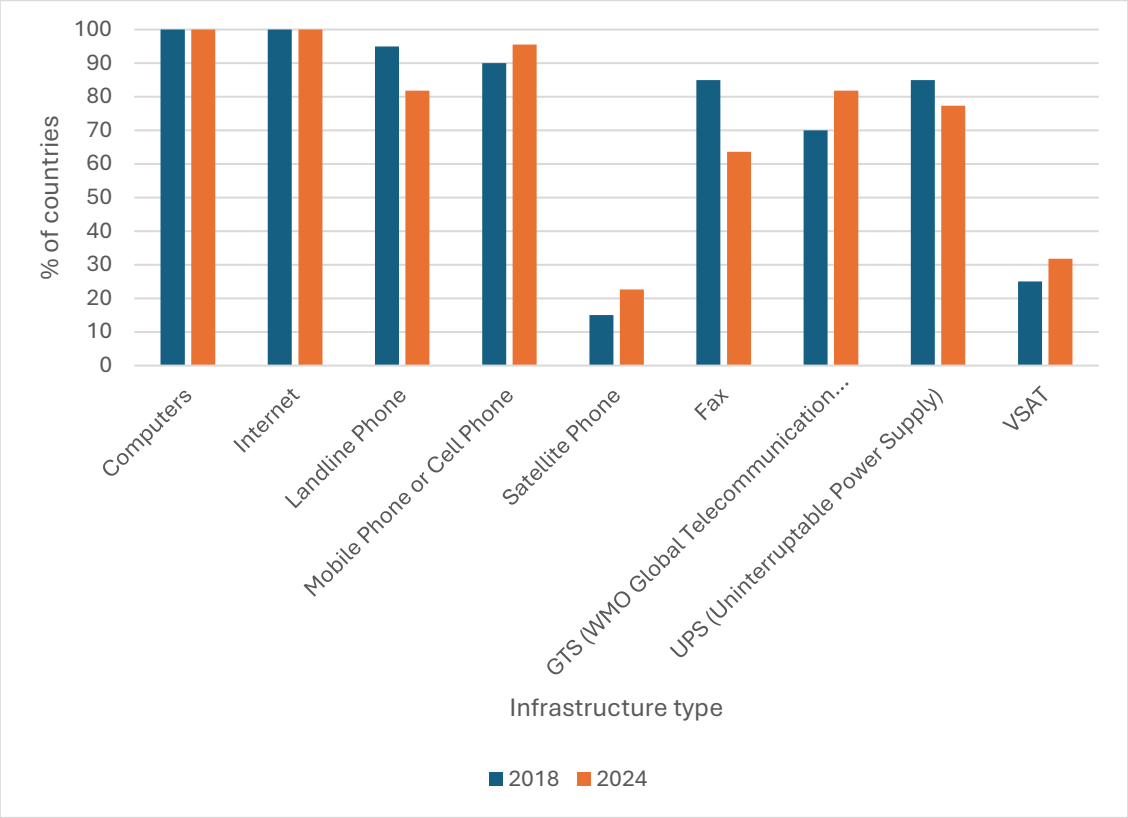


Figure 40: Infrastructure availability to support 24x7 operations

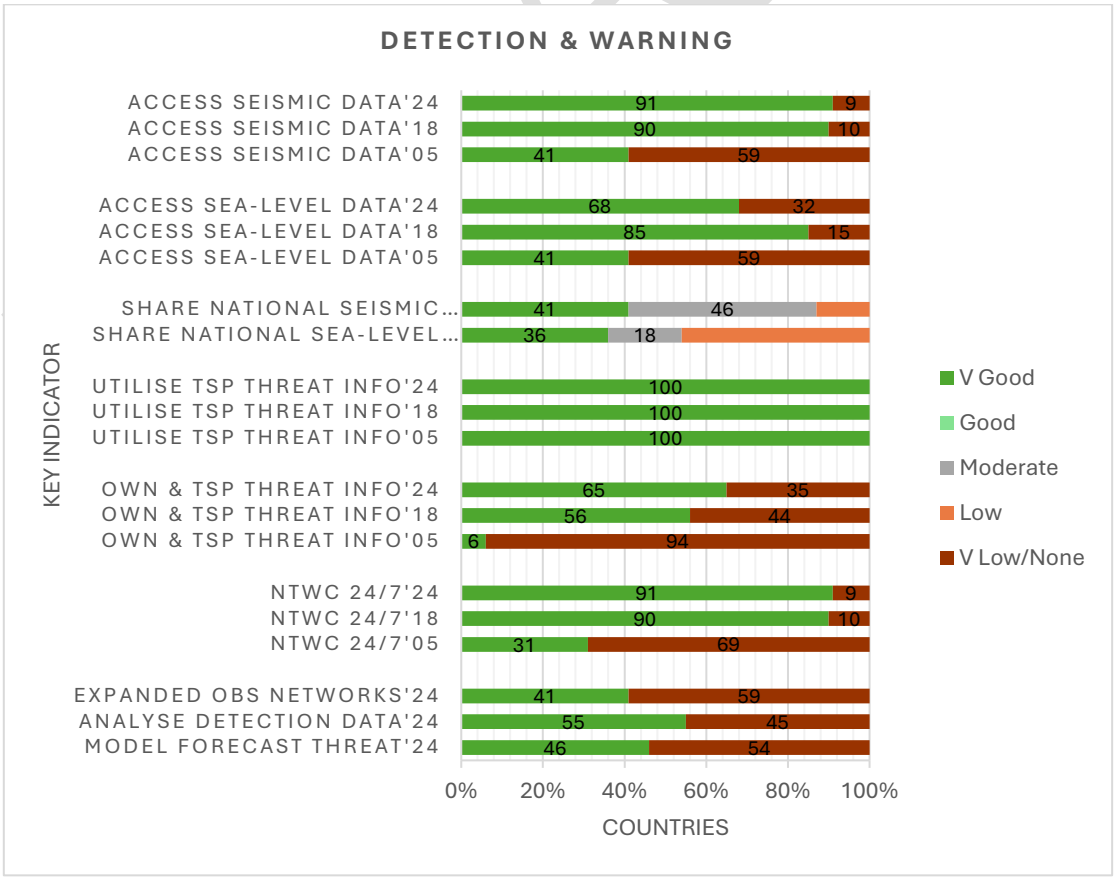


Figure 41: Summary country activity and capacity status for detection and warning.

Email, SMS, Radio and Television remain in widespread use (>90% of countries) for disseminating tsunami information (warning, public safety action, etc (Figure 42). There are notable changes from 2018, including a significant reduction in the number of countries using Fax (85% to 50%) (actually a positive development) and an increased use of Social Media (65% to 96%). With regards to communication methods used in communicating and responding to emergency situations, for National Disaster Management Offices (DMOs), telephones, email and SMS are all widely used in many countries (90% or more). The situation is similar for Local DMOs (80% or more). Use of Fax has diminished significantly since the 2018 survey results for both National DMOs (90% to 55%) and Local DMOs (75% to 45%). For communicating with the media, the telephone and email remain the most widely used methods, but again, use of the Fax has diminished (75% to 45%). Unsurprisingly, the pattern of responses for the general public and coastal communities is similar, and more than 50% of countries use to some extent SMS and sirens to reach these groups. Other communication methods mentioned by countries included websites, social media, radio, dedicated applications, broadcast alert systems, and television. To reach all in the community, dissemination methodologies and technologies must take into consider and service all inclusively those in the community with disabilities, the young and the old, and all genders.

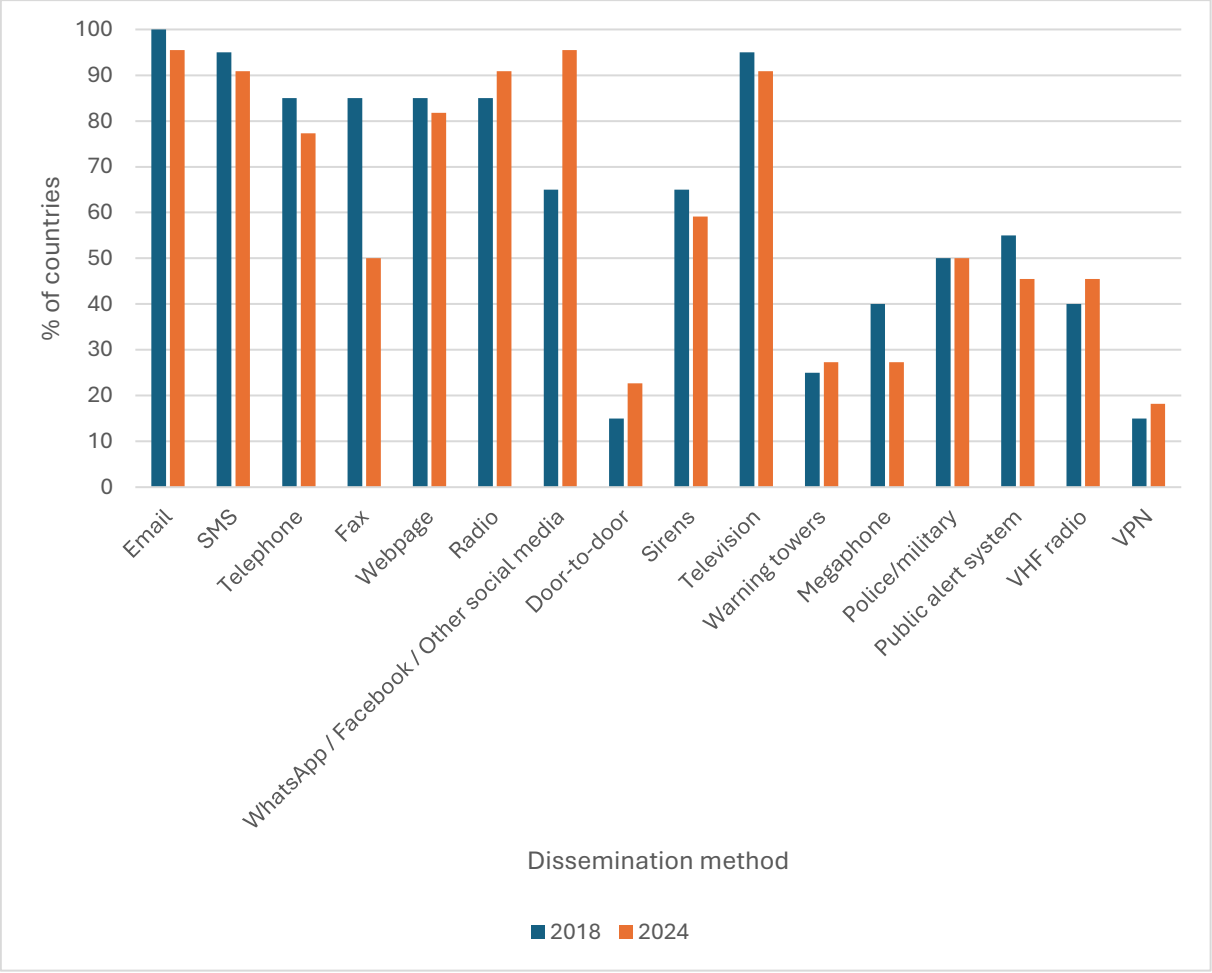


Figure 42: How tsunami information is disseminated

Respondents were asked to confirm the communication methods used in communicating between groups in emergency situations (Figure 43). For National DMOs, telephones, email and SMS are all widely used in many countries (90% or more). The situation is similar for Local DMOs (80% or more). Use of Fax has diminished significantly since the 2018 survey results for both National DMOs (90% to 55%) and Local DMOs (75% to 45%). For communicating with the media, the telephone and email remain the most widely used

methods, but again, use of the Fax has diminished (75% to 45%). Unsurprisingly, the pattern of responses for the general public and coastal communities is similar, and more than 50% of countries use to some extent SMS and sirens to reach these groups. Other communication methods mentioned by countries included websites, social media, radio, dedicated applications, broadcast alert systems, and television.

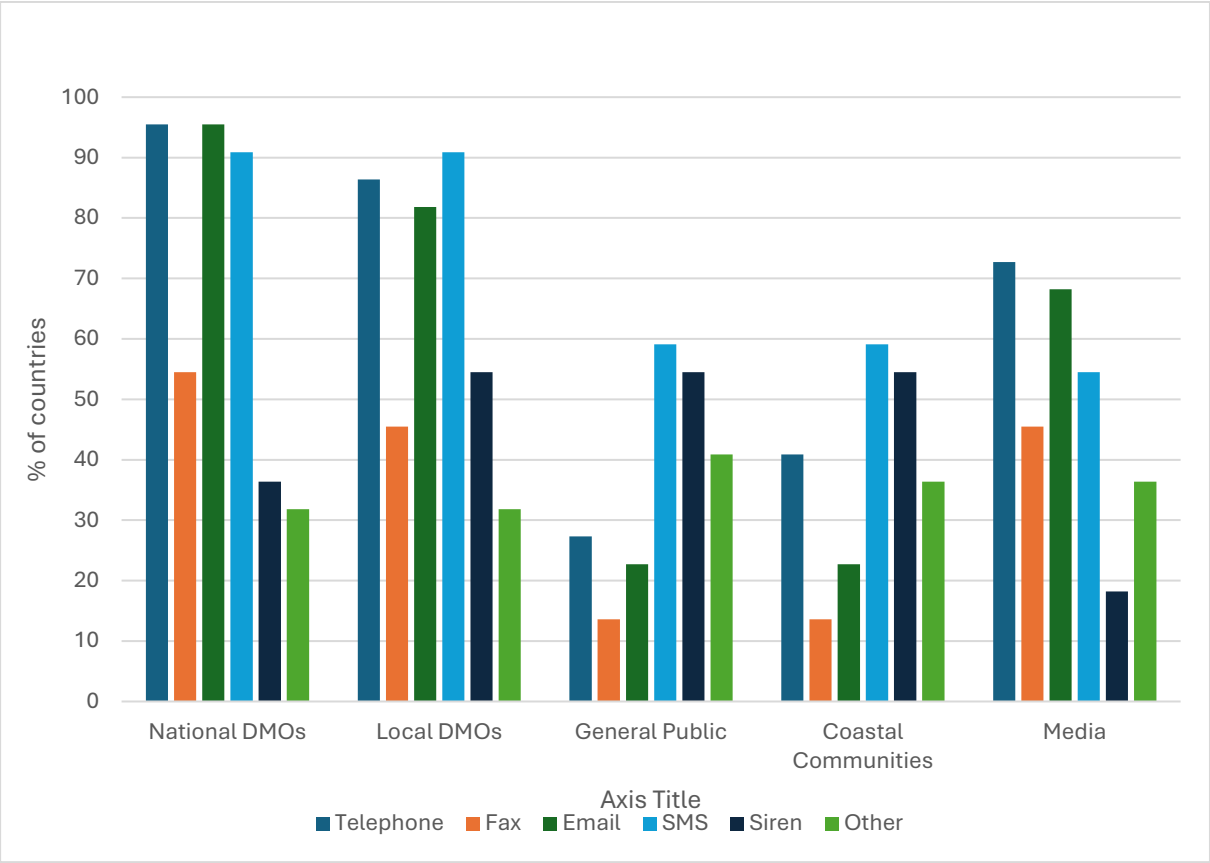


Figure 43: Communication methods for emergency response

With regards to warning dissemination, the overall survey results (Figure 44) plus a forensic analysis of national tsunami warning chains of all countries (Figure 45), undertaken during Standard Operating Procedure (SOP) workshops held in 2023 organised by the ICG/IOTWMS Secretariat and the UNSECO-IOC IOTIC indicate further effort is required nationally by some countries to ensure SOPs [13] underpin every link in the warning chain, especially in the downstream components, to ensure early warnings reach all in the community.

17 (77%) countries reported enhancements to their national warning SOPs since 2018 and since the SOP workshops. These included a review of national warning SOPs and/or response plans, quality management certification, implementation of new SOPs and testing under environments, such as IOWave exercises and national drills. The UNESCAP funded project in the NW Indian Ocean has already developed more robust national tsunami warning chains underpinned by SOPs for that sub-region. The SOP training provided by the ICG/IOTWMS Secretariat and IOTIC in 2023 now needs to be followed up in the remaining identified countries with support. As well as further developing the SOPs themselves, capacity development is also required in associated human resources and infrastructure by many countries. Efforts by the ICG/IOTWMS

[13] UNESCO-IOC. 2017. Plans and Procedures for Tsunami Warning and Emergency Management. Paris, Intergovernmental Oceanographic Commission of UNESCO 2017. 72 pp. (IOC Manuals and Guides No.76)

to enhance national tsunami warning chains will help underpin efforts by the UN EW4ALL initiative, as there are many common elements for other hazards.

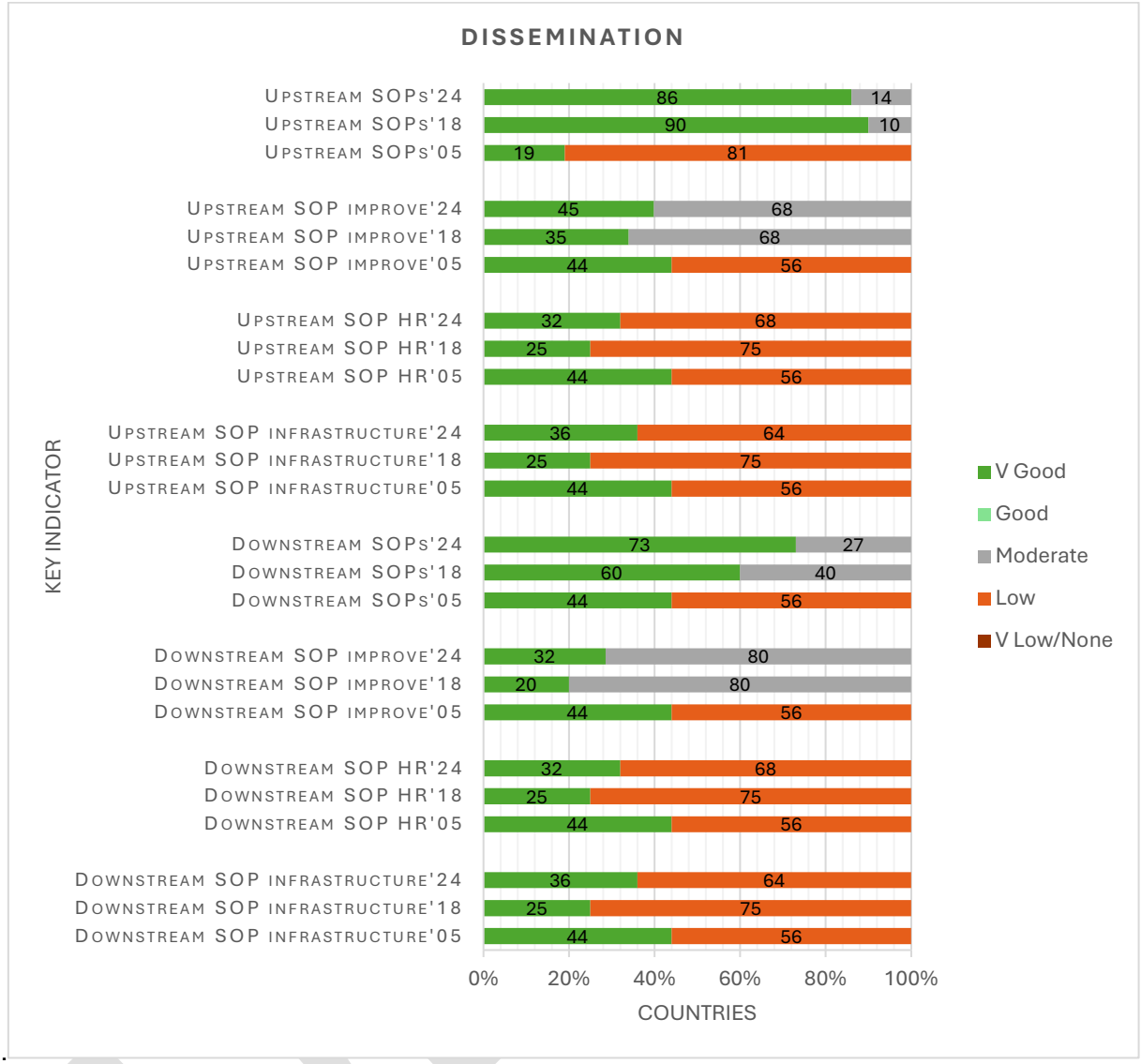


Figure 44: Summary country activity and capacity status for warning dissemination.

From the survey, most countries have SOPs that address the operation of a 24/7 emergency operation centre (86%), receiving information from the NTWC (96%), and response criteria and decision making (91%) (Figure 46). Although to a lesser extent than reported in the 2018 survey, these results also indicate that many countries still require support to develop SOPs in all three aspects (55 – 68%). They also require support to develop human resources in these areas, especially 24/7 emergency operations and response criteria/decision making (64 – 68%). Support to develop infrastructure across all three aspects is also required in many countries (55 – 64%).

The survey responses also indicate that more than 90% of countries have SOPs that address warning dissemination and communication with the NTWC, while more than 70% of countries have SOPs that address all aspects of emergency response (Figure 47). However, despite widespread availability and although to a lesser extent than reported in the 2018 survey, a majority of countries still require support to develop SOPs (55 – 68%), support to develop human resources (59 - 68%) and support to develop infrastructure across all seven aspects (50 – 68%).

20 (91%) countries indicated their willing to share SOPs with other countries to facilitate development.

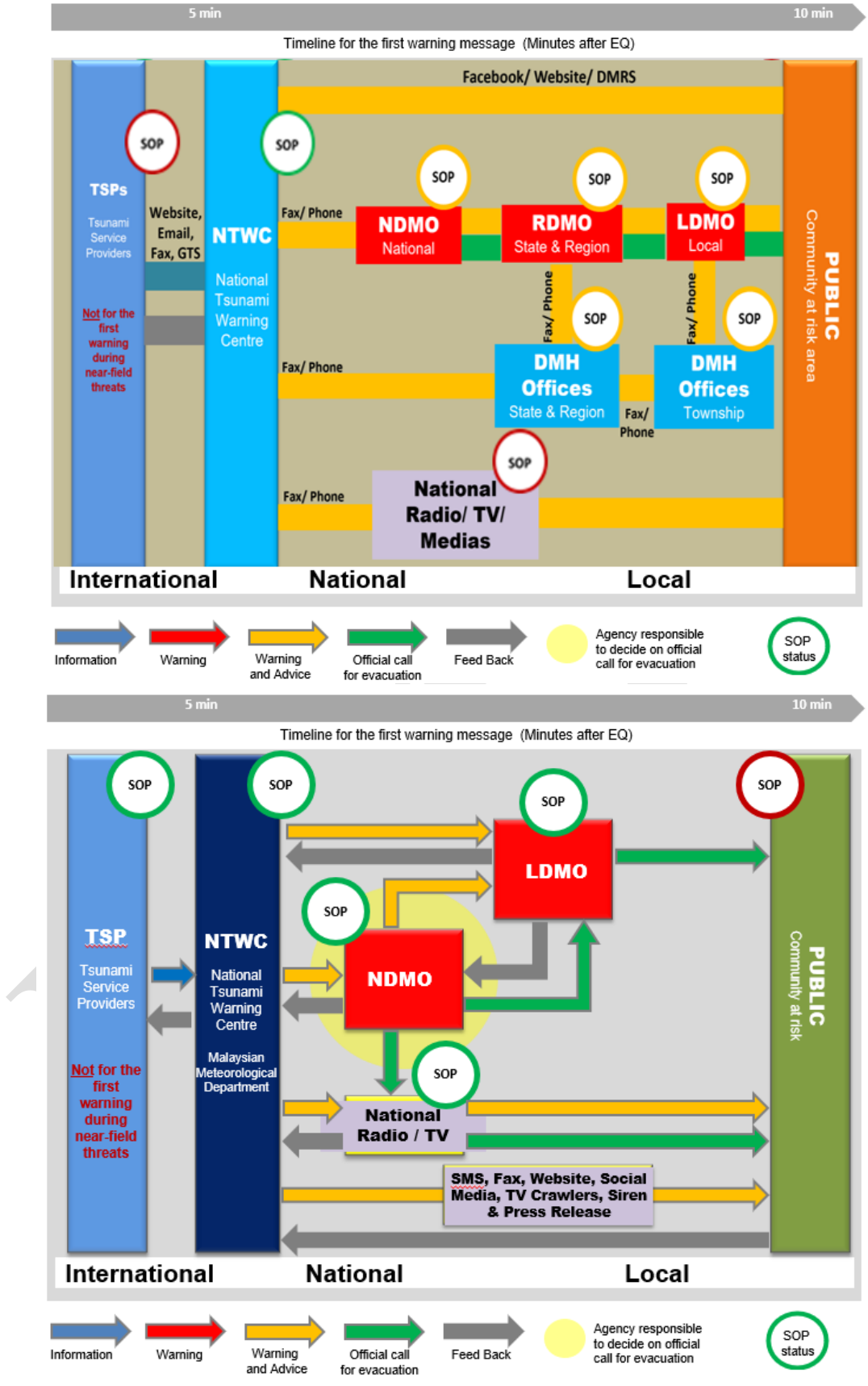
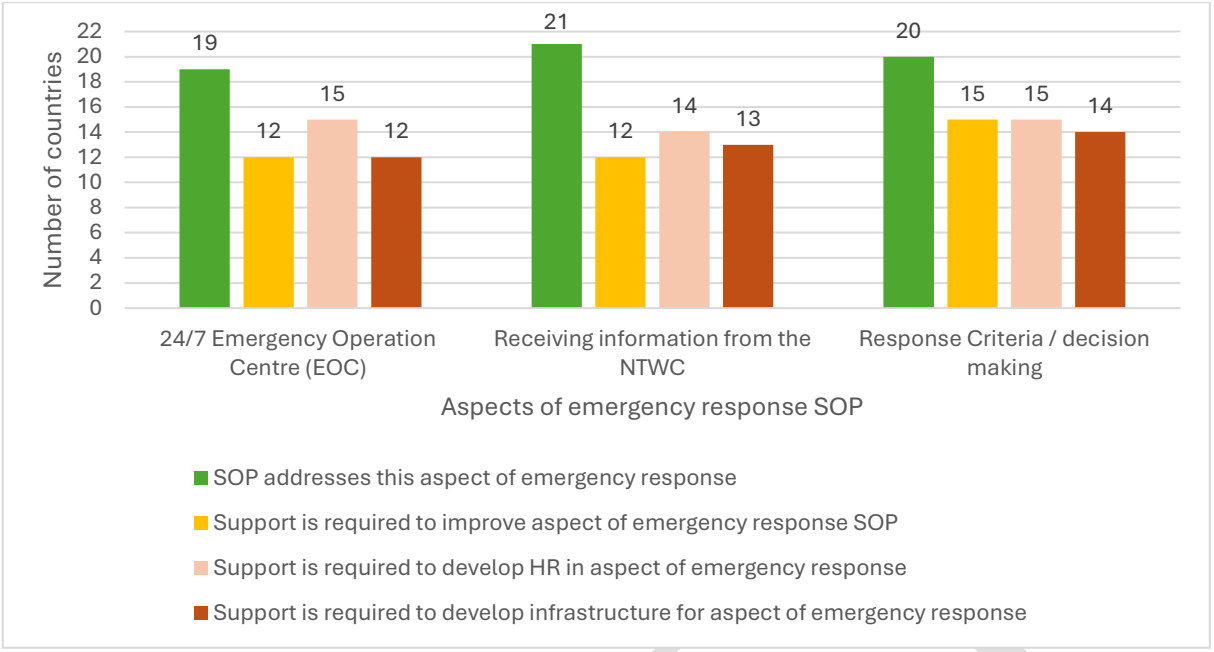


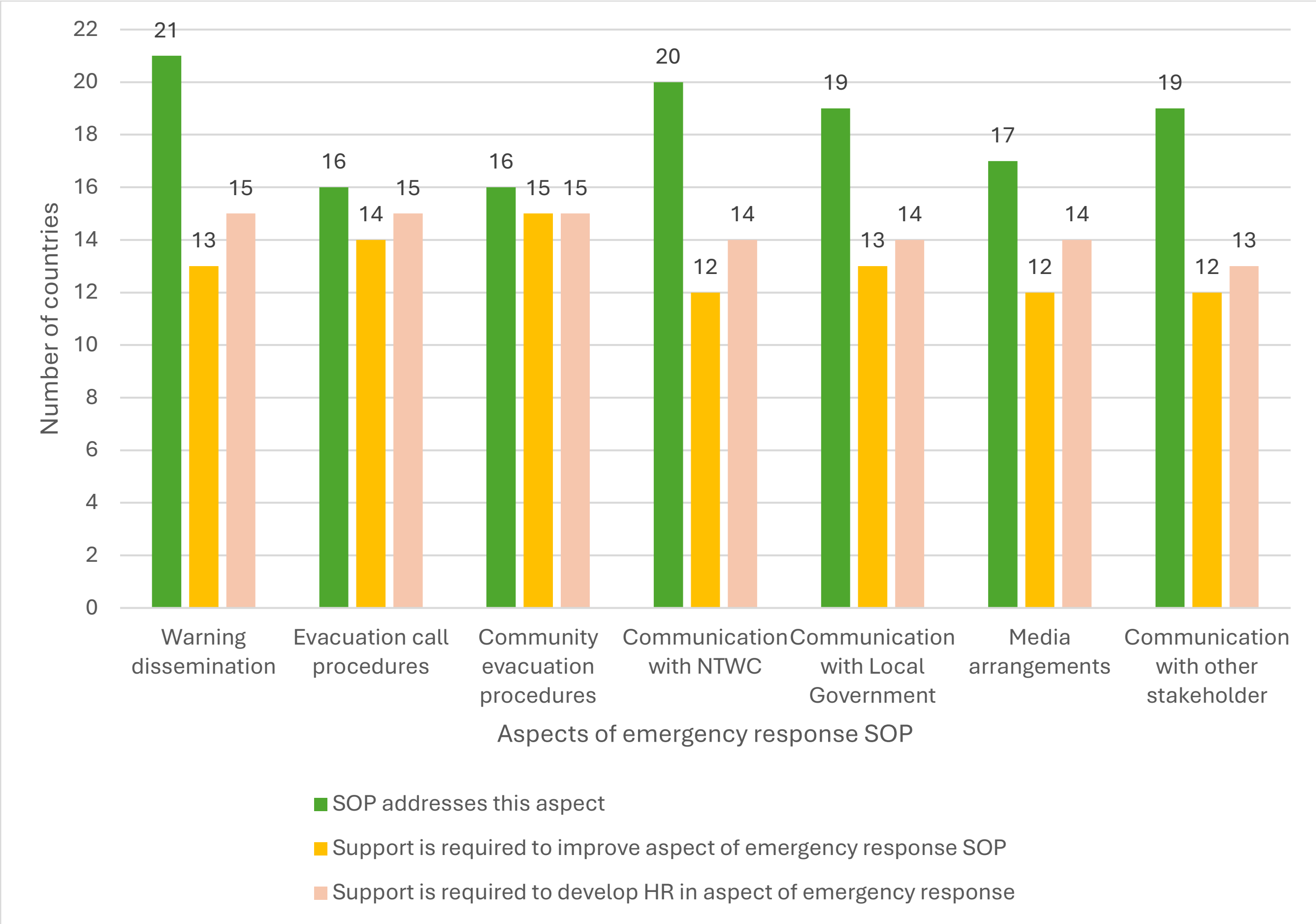
Figure 45: Examples of national tsunami warning chains and SOP status, showing differences from country to country due to different national arrangements, plus different status of required SOPs



	ASPECT OF UPSTREAM EMERGENCY RESPONSE SOP											
	24/7 Emergency Operation Centre (EOC)				Receiving information from the NTWC				Response criteria / decision making			
	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure
Australia	●	○	○	○	●	○	○	○	●	○	○	○
Bangladesh	●	●	●	●	●	●	●	●	●	●	●	●
Comoros												
France Indian Ocean Territories	●	○	○	○	●	○	○	○	●	●	●	●
India	●	○	●	○	●	○	○	○	●	○	○	○
Indonesia	●	●	●	●	●	●	●	●	●	●	●	●
Iran	○	●	●	●	●	●	○	○	●	●	●	●
Kenya	●	●	●	●	●	●	●	●	●	●	●	●
Madagascar	●	●	●	●	●	●	●	●	●	●	●	●
Malaysia	●	○	●	○	●	○	●	○	●	●	●	○
Maldives	●	●	●	●	●	●	●	●	●	●	●	●
Mauritius	●	○	○	○	●	○	○	○	●	○	○	○
Mozambique	●	●	●	●	●	●	●	●	●	●	●	●
Myanmar					●	●	●	●				
Oman	●	●	●	●	●	●	●	●	●	●	●	●
Pakistan	●	○	●	●	●	○	●	●	●	●	●	●
Seychelles	●	●	●	●	●	●	●	●	●	●	●	●
Singapore	●	○	○	●	●	○	○	○	●	○	○	○
South Africa	●	●	●	●	●	○	●	●	●	●	●	●
Sri Lanka	●	●	●	●	●	●	●	●	●	●	●	●
Thailand	●	●	●	●	●	●	●	●	●	●	●	●
United Arab Emirates	●	○	○	○	●	○	○	○	●	○	○	○

● = Yes ○ = No Blank = No Response

Figure 46: Support required to develop SOPs for downstream operations and decision making



ASPECT OF DOWNSTREAM EMERGENCY RESPONSE SOP	Warning dissemination				Evacuation call procedures				Community evacuation				Communication with NTWC				Communicaton with local government				Media arrangements				Communication with other stakeholders			
	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure	SOP addresses this aspect	Support required to develop/improve SOP	Support required to develop human resources	Support required to develop infrastructure
Australia	●	●	●	○	●	●	●	○	●	●	●	●	●	●	●	○	●	●	●	○	●	●	●	○	●	●	●	○
Bangladesh	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Comoros																												
France Indian Ocean Territories	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○
India	●	○	○	○	●	○	●	○	●	○	●	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○
Indonesia	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Iran	●	○	●	●	●	○	○	○	●	●	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○
Kenya	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Madagascar	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Malaysia	●	○	●	●	●	○	●	○	●	○	●	○	●	○	●	○	●	○	●	○	●	○	●	○	●	○	●	○
Maldives	●	●	●	●	○	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Mauritius	●	○	○	○	●	●	○	●	●	●	○	●	●	○	○	○	●	○	○	●	●	○	○	○	●	○	○	○
Mozambique	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Myanmar	●	●	●	●																								
Oman	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Pakistan	●	●	●	●	○	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	○	○
Seychelles	●	●	●	●	○	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●
Singapore	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○
South Africa	●	○	○	●	○	●	●	●	○	●	●	●	●	○	●	●	●	●	●	●	○	●	●		○	●	●	●
Sri Lanka	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●	●
Thailand	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
United Arab Emirates	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○	●	○	○	○

● = Yes ○ = No Blank = No Response

Figure 47: Support required to develop SOPs for warning dissemination and downstream response

Public Awareness, Preparedness, and Response

In many countries the National Disaster Management Office (NDMO) (46%) takes responsibility for tsunami public awareness programmes in their countries (Figure 48), but the National Tsunami Warning Centre (NTWC) (23%) and Local Disaster Management Office (LDMO) (9%) were also identified by some countries. Several countries reported that is the responsibility of multiple organisations, including the NDMO, LDMO, NTWC and international organisations.

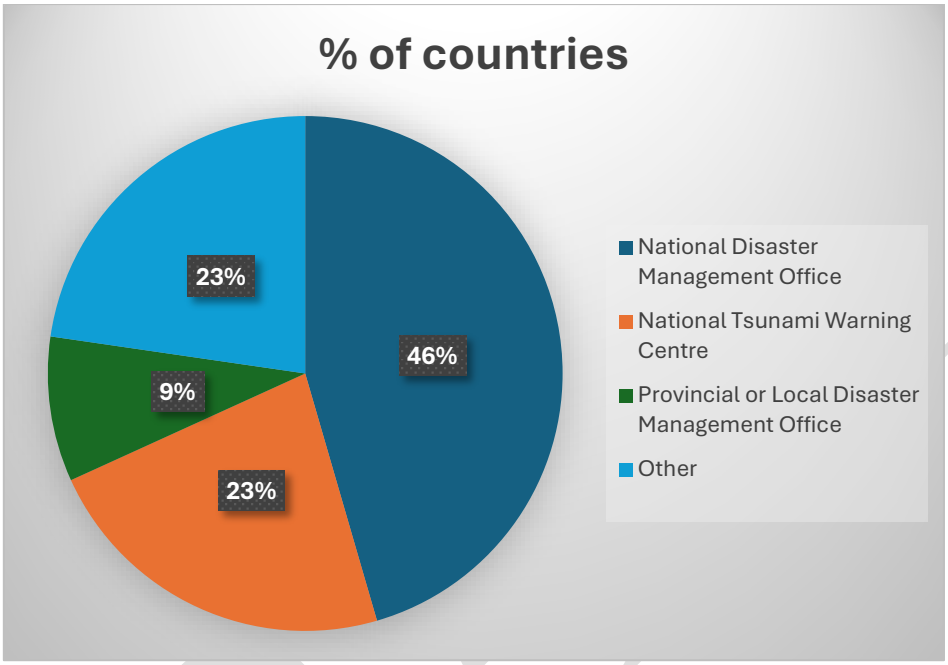


Figure 48: Organisation responsible for tsunami public awareness programmes

The UNESCO-IOC IOTIC continues to be the major source of training and developer of education materials IOTIC remains a significant asset to the ICG/IOTWMS. In a similar outcome to 2018, posters, leaflets and flyers, booklets and video/oral media were identified as being used by the majority of countries (Figure 49). Education materials such as information boards and school curricular were also used in nine (41%) countries. Less common were the use of teaching kits, indigenous knowledge, signage and public evacuation maps. Among other responses, were a tailored-to-Australia conditions online tsunami education resource called "Tsunami: The Ultimate Guide" and a sensitisation campaign. 19 (86%) countries confirmed that they are willing to share these education and awareness materials with the UNESCO-IOC IOTIC and other countries.

Countries were asked to confirm whether or not they carried out a range of public awareness activities (Figure 50). School and child related awareness activities and tsunami exercises, as well as global awareness raising days, were the most widely carried out across respondent countries. In particular, there is a significant increase in the reporting of activities linked to the Tsunami World Awareness Day (WTAD) and International Day for Disaster Risk Reduction (IDDRR) when compared to the 2018 survey results (45% to 73%).

Countries were asked to indicate any areas in which they required support from the IOTIC to develop or enhance public awareness in their country (Figure 51). Support in the development of tsunami awareness programmes, activities or campaigns, participation by international agencies or experts, provision of general tsunami awareness materials were the most widely requested by countries (more than 75%). Eight (36%) countries also offered to support other Member States to develop or enhance public awareness. The type of support on offer included providing experts or sharing of their materials, conduct or support training activities.

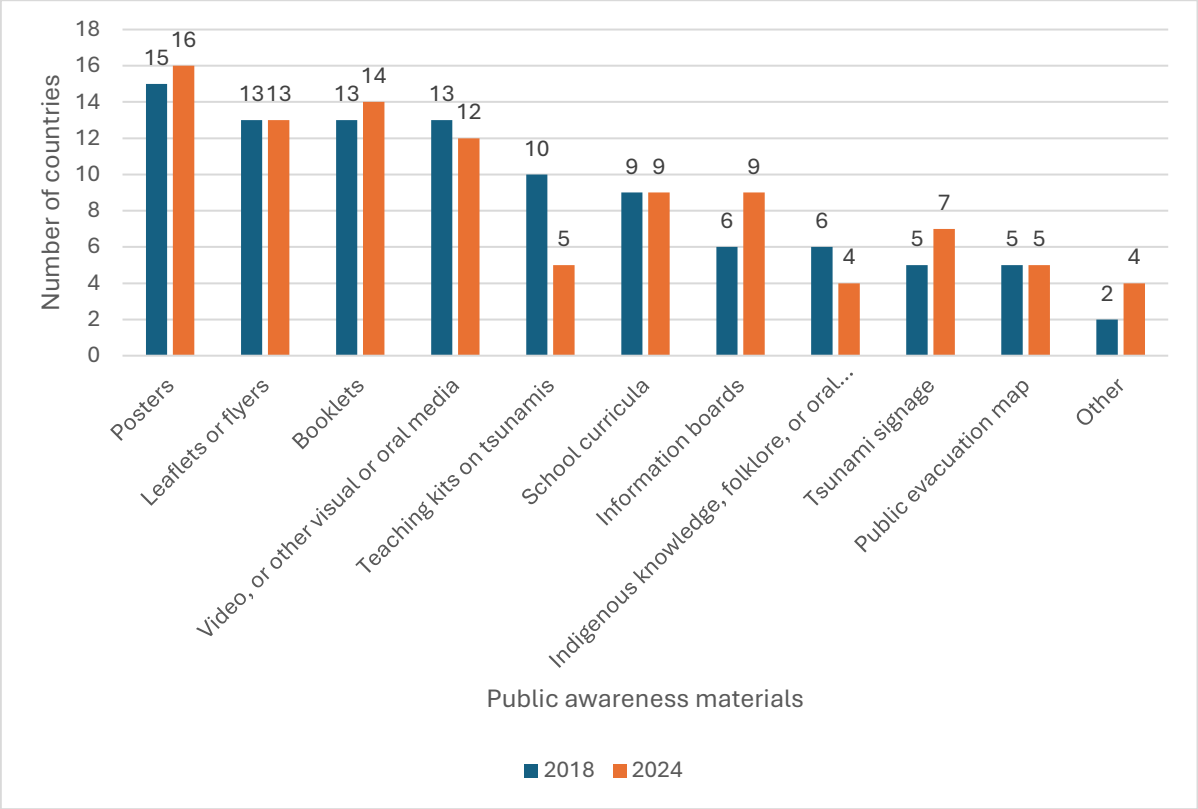


Figure 49: Types of public awareness materials

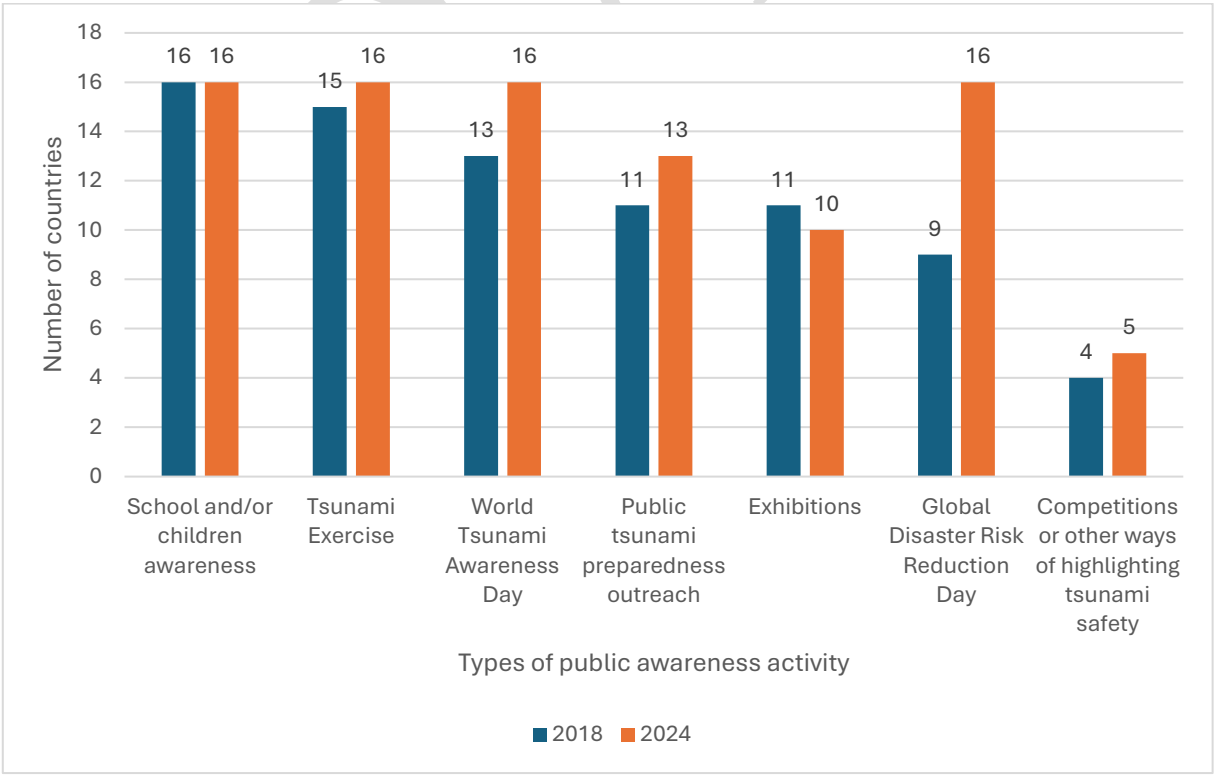
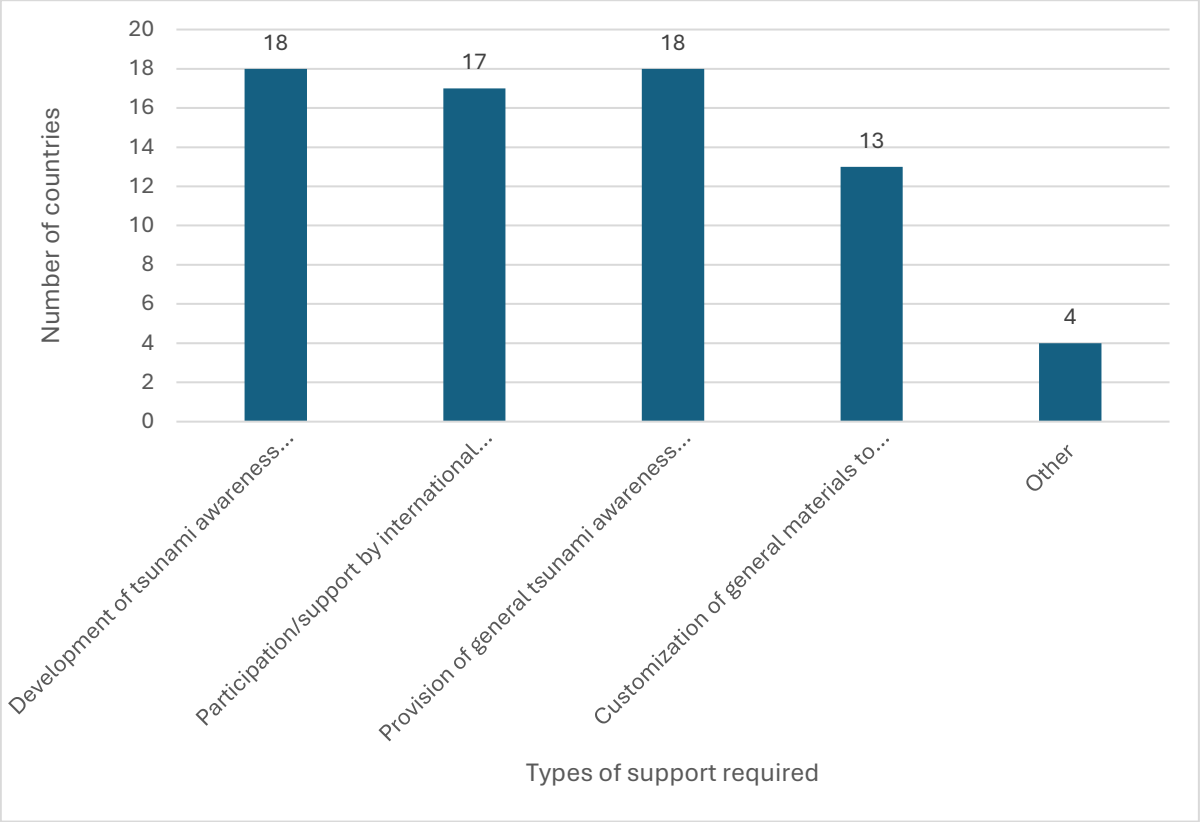


Figure 50: Types of public awareness activity



	Support required for public awareness activity				
	Provision of general tsunami awareness materials	Customisation of general materials to country or community	Development of tsunami awareness programmes, activities or campaigns	Participation/support by international agencies or experts to your country's activities	Other
Australia	●	●	●	●	●
Bangladesh	●	●	●	●	○
Comoros	●	●	●	●	○
France Indian Ocean Territories	○	○	○	○	○
India	●	○	●	○	○
Indonesia	●	●	●	●	●
Iran	●	○	●	●	○
Kenya	●	●	●	●	○
Madagascar	●	●	●	●	○
Malaysia	●	●	●	●	○
Maldives	●	●	●	○	○
Mauritius	●	●	●	●	●
Mozambique	●	○	●	●	○
Myanmar	●	●	●	●	○
Oman	●	●	●	●	○
Pakistan	○	○	○	●	○
Seychelles	●	●	●	●	○
Singapore	○	○	○	○	○
South Africa	●	○	●	●	○
Sri Lanka	●	●	●	●	●
Thailand	●	○	●	●	○
United Arab Emirates	○	○	○	○	○

● = Yes ○ = No

Figure 51: Support required for public awareness activities

Evacuation planning is a key component of effective community response. Only 11 (50%) countries have evacuation maps. The other 11 (50%) countries require support to develop evacuation maps. Countries were asked to indicate the availability of different types of evacuation infrastructure in their country (Figure 52). The results reveal an increase in the provision of evacuation shelters within countries when compared to the 2018 survey (55% to 68%), while natural or artificial hills for vertical evacuation also remain widely reported and identified by 59% of countries. Evacuation signage (41%) and vertical evacuation structures (32%) remain less utilised. 14 (64%) countries also reported that evacuation infrastructure is incorporated into evacuation plans. SOPs are required for evacuation in most countries.

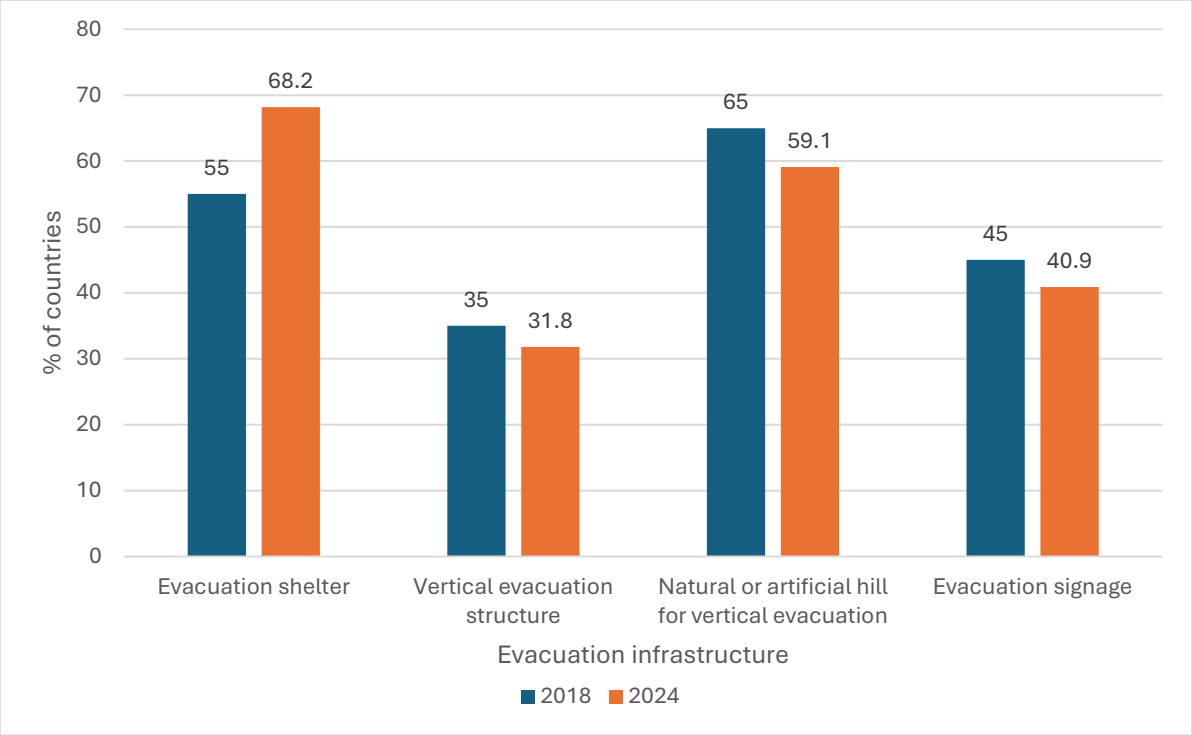


Figure 52: Evacuation infrastructure

In summary, since 2005 there has been considerable production of awareness materials and delivery of community awareness activities to help prepare at-risk communities. UNESCO-IOC IOTIC continues to provide substantial support in these endeavours, including training. The request for more support by countries most likely reflects the appreciation of the high quality, utility, and need for the services provided by UNESCO-IOC IOTIC, especially as efforts by countries focus and grow with regards to the massive task of making at-risk communities prepared and resilient to the tsunami threat (Figure 53). As work focus more on local communities, even more effort and resources are required to translate education materials and training into local languages. More effort and resources are required to ensure all communities at-risk have evacuation plans and procedures in place. Collaboration between United Nations Development Programme (UNDP) and UNESCO-IOC is importantly seeing the growth of education and training programmes for schools. Collaboration between United Nations Office for Risk Reduction (UNDRR) and UNESCO-IOC on events, such as World Tsunami Awareness Day, is utilisation major opportunities to advance community awareness and preparedness.

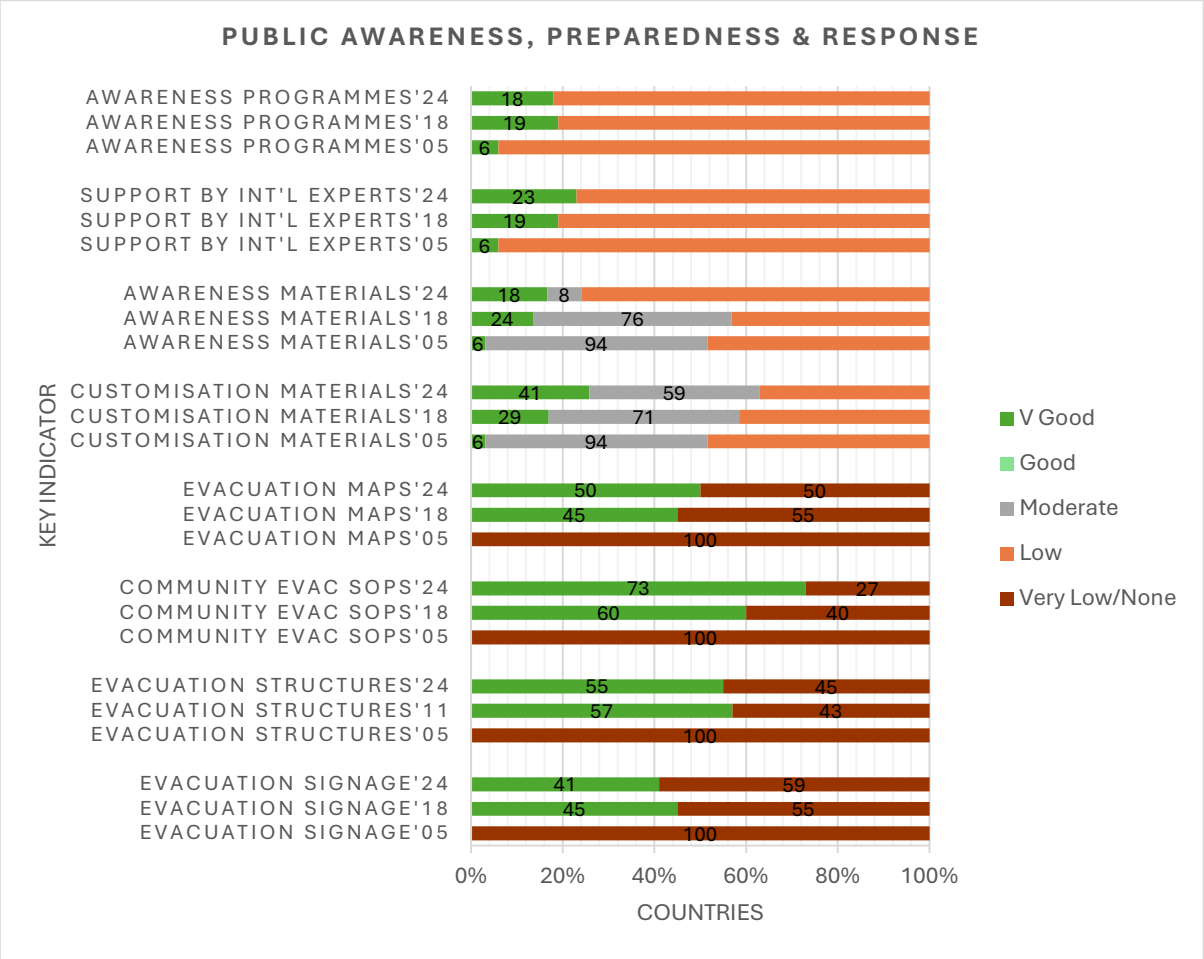


Figure 53: Summary country activity and capacity status for public awareness, preparedness, and response.

Tsunami Ready Recognition

Countries were asked a series of questions about their involvement in the UNESCO-IOC Tsunami Ready Recognition Programme (TRRP) or other similar national tsunami resilience and preparedness related initiatives. The UNESCO-IOC TRRP is implemented as a voluntary, performance-based, community recognition programme that promotes an understanding of the concept of readiness as an active collaboration among national and local warning and emergency management agencies and government authorities, scientists, community leaders, and the public. UNESCO-IOC TRRP was only in pilot mode in a couple of countries at the time of the 2018 assessment. Therefore, the survey questions in 2024 differed significantly from 2018 and comparable data is often not available.

Firstly, countries were asked to confirm whether they have an interest in participating in the UNESCO-IOC TRRP. 13 (59%) countries confirmed that they are already participating in (although not yet necessarily implementing) UNESCO-IOC TRRP, while eight (36%) responded that they are not currently doing so and therefore less prepared. Of those not currently participating, six of the eight countries responded that they have plans to do so in the near future, while two do not and will be least prepared.

Six (27%) countries responded that they are currently implementing other initiatives and programmes. Examples included the village disaster resilient programme (DESTANA) in Indonesia, as well as a range of national level campaigns and exercises, such as tabletop exercises, training of trainers, awareness raising workshops, and as part of multi-hazard workshops. Indonesia has also extended their programme to include

tsunami ready recognition for critical infrastructure (such as airports). The other 14 (63%) countries responded they are not currently implementing any other programmes or initiatives. Two (10%) have no plans for any programmes, presumably based on a relatively lower risk of tsunamis impacting those countries.

Countries were next asked to estimate what number of villages, cities/districts and provinces/state levels are at risk of a tsunami threat to be able to determine the scale of UNESCO-IOC TRRP or similar national initiatives required (Table 4). Many countries unfortunately did not respond. While it is in any respect difficult to make meaningful comparisons across such a diverse group of countries with different governance structures, population sizes, and varying levels of tsunami hazard exposure, it is notable that 19 (86%) countries are collecting this data for at least one administrative level, while half of the respondent countries are providing estimates to the village level.

Table 4: Number of villages, cities/districts and provinces/state levels at risk to tsunami

Country	Village	City / District	Province / State
Australia			
Bangladesh		14	
Comoros	50	20	3
France Indian Ocean Territories	36		
India	3174	73	13
Indonesia	5744	255	26
Iran	50	6	2
Kenya			4
Madagascar			
Malaysia			3
Maldives	172	5	198
Mauritius		6	
Mozambique			
Myanmar	1000	70	5
Oman	60	23	7
Pakistan	0	2	2
Seychelles		27	
Singapore	0	0	0
South Africa			3
Sri Lanka		14	5
Thailand	509	27	6
United Arab Emirates			2

Figure 54: Tsunami Ready recognition of communities in Indonesia and India

Five (23%) countries reported having a National Tsunami Ready Board (NTRB), which is responsible for initiating and guiding the community on the steps for Tsunami Ready recognition and for the review and approval of the community's Tsunami Ready application. Of the 17 (77%) countries that reported not having a NTRB, nine reported an existing coordination mechanism that can fulfil this role. These included a range of National Councils, Committees and Advisory Groups.

When asked which institution(s) should be involved in the implementation of UNESCO-IOC TRRP or similar national initiative, country responses varied greatly. They ranged from individual institutions (such as the NTWC), to a variety of national and local disaster management agencies, national and local government agencies, armed forces and emergency services, and humanitarian agencies.

12 (55%) countries reported that some communities (for example, villages, cities, districts, provinces or states) are currently working towards implementing or are interested in implementing the UNESCO-IOC TRRP or similar national initiative. However, at this stage only two countries (India and Indonesia) reported having achieved recognition through UNESCO-IOC TRRP or a similar national initiative (Figure 54).

Countries were then asked a series of questions about their national capacity to implement different aspects of UNESCO-IOC TRRP or similar national initiatives, including the extent to which each aspect can be achieved entirely or partially through mobilising national experts and funding, or whether there is a strong need for international technical expertise. The individual country responses are summarised in Figure 55 and the needs overall against the 12 Tsunami Ready Indicators in Figure 56.

Countries were asked to consider what challenges inhibit the implementation of TRRP or similar national initiatives (Figure 57). The most significant challenges were limited resources and limited awareness, each reported by 11 countries (50%). Other significant challenges included that tsunami is not a high priority (46%), there is limited support from government (46%), there is limited activity (41%), and a lack of community interest (36%). Only three (14%) countries reported that none of the identified challenges inhibited implementation. The other challenges identified by at least one country included the infrequent nature of tsunami hazard events and the perceived lack of tangible benefits demonstrated so far for the UNESCO-IOC TRRP.

In summary, work has begun by some countries on initiating the UNESCO-IOC TRRP or similar national initiatives fundamental to getting 100% at-risk communities prepared and resilient to the tsunami threat by 2030 (Figure 58). The task is massive, with many more resources and training required at the regional and especially national levels. The capacity development requirements have been identified.

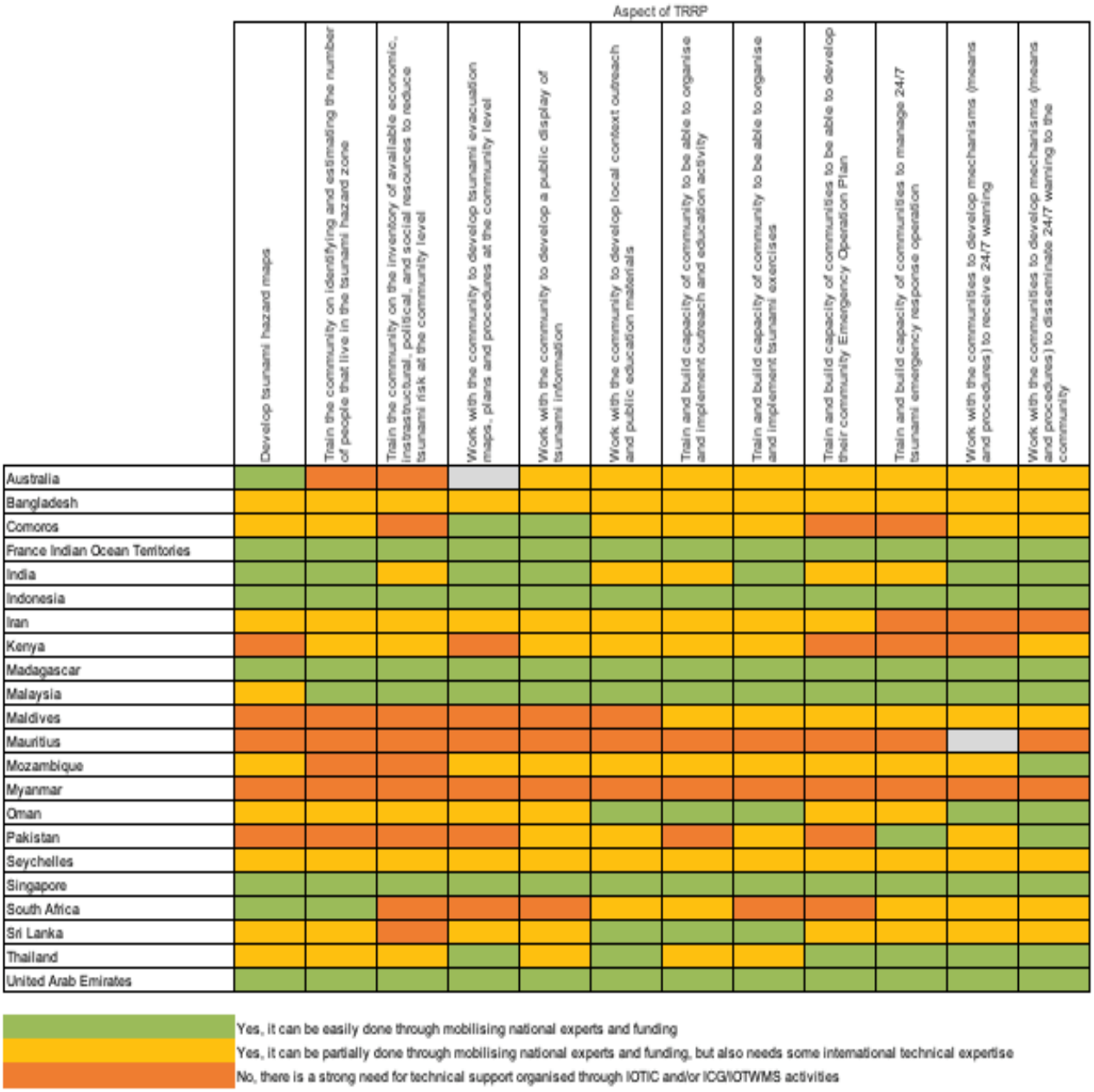


Figure 55: Country capacity according to the indicators/aspects of Tsunami Ready Recognition

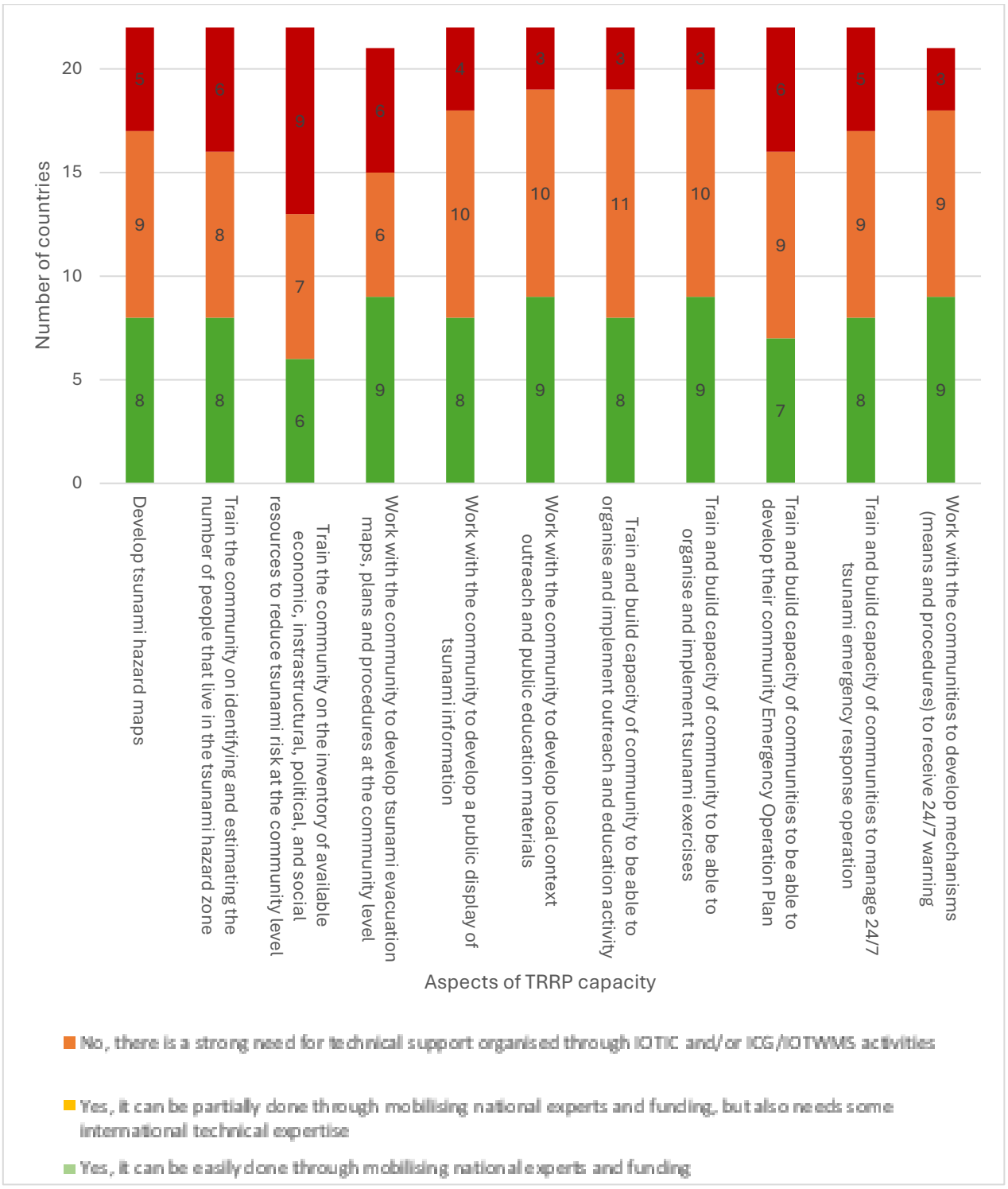


Figure 56: Summary of national capacity and needs according to different aspects of the UNESCO-IOC Tsunami Ready Recognition Programme (TRRP)

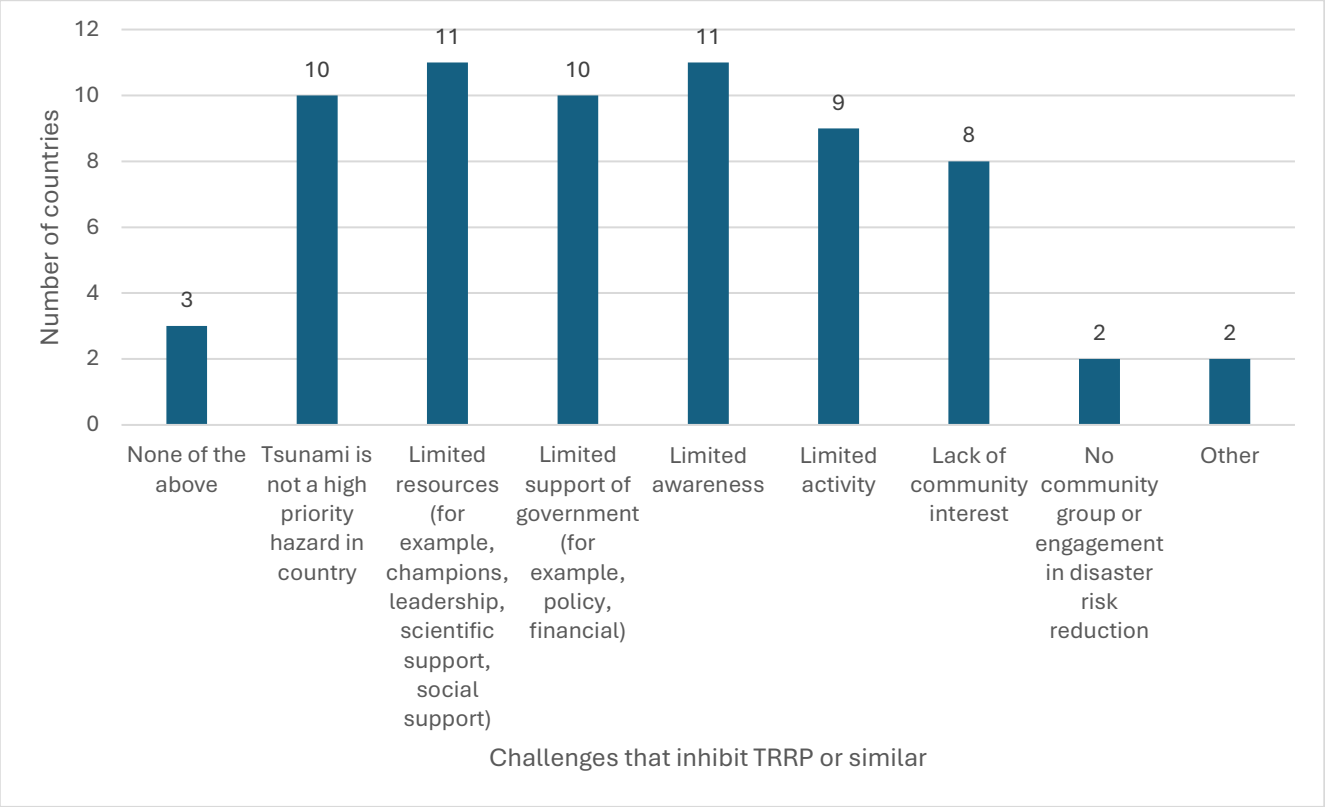


Figure 57 Challenges that inhibit the implementation of UNESCO-IOC Tsunami Ready Recognition Programme (TRRP) or similar national initiatives

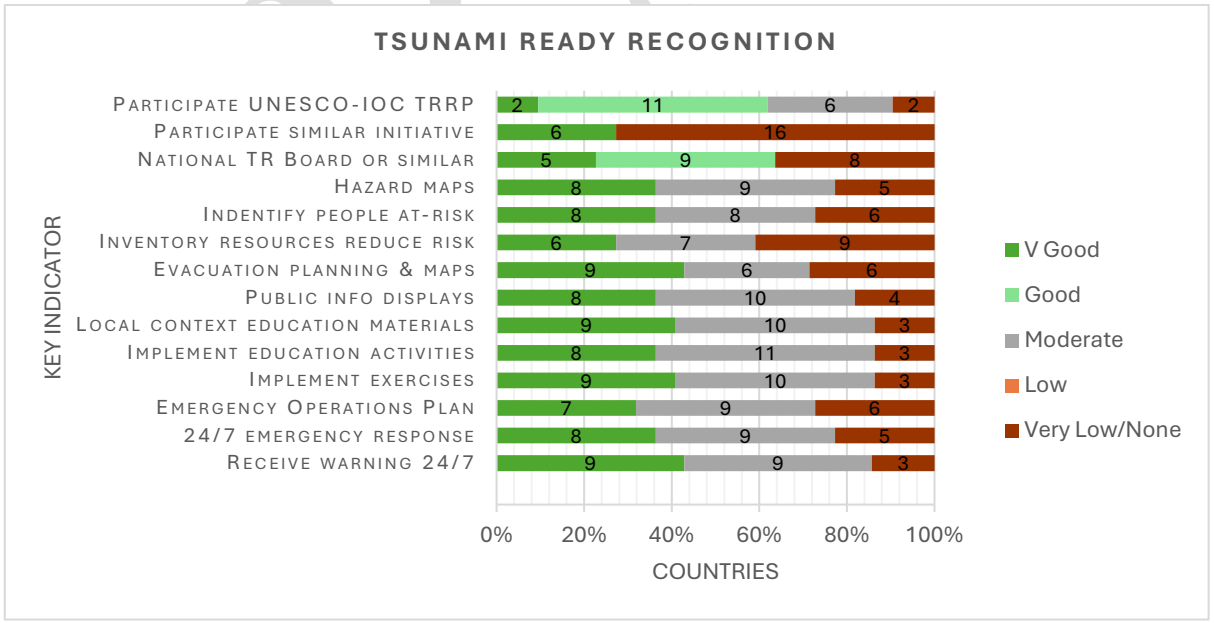


Figure 58: Country activity and capacity status for Tsunami Ready Recognition.

Exercises

The interoperable system developed by the UNESCO-IOC ICG/IOTWMS is routinely tested and exercised through six-monthly communication tests and biennial IOWAVE Exercises organised by the ICG/IOTWMS and the ICG/IOTWMS Secretariat (Figure 59).

Figure 59: Indian Ocean exercises (IOWave) coordinated by the UNESCO-IOC ICG/IOTWMS are held across the Indian Ocean every two years

14 (64%) countries reported that they have tsunami exercises[14] incorporated within their national policies and 14 (64%) countries have tsunami exercises incorporated within national guidelines. Six (27%) countries have incorporated them within national policies and guidelines. 21 (96%) countries reported conducting tsunami exercises at one or more levels during the inter-sessional period. Exercises were conducted at the national level within 13 (59%) countries, and at the regional, city, village and school levels in more than 40% of countries (Figure 60). Encouragingly the number of countries undertaking exercises at school level and city level have increased.

Countries were asked to report on the type of tsunami exercise activities that have been undertaken in their countries (Figure 61) during the inter-sessional period (i.e. between ICG Meetings). 20 (91%) countries reported that they took part in the Indian Ocean Wave exercise. Tabletop exercises (intra- and inter-

[14] UNESCO-IOC. 2013. How to Plan, Conduct and Evaluate UNESCO/IOC Tsunami Wave Exercises. 2013. Paris, UNESCO (IOC Manuals and Guides No. 58 rev.)

organisational), as well as national and local tsunami exercises were undertaken by 50% of responding countries or more. The results show a small reduction in the conduct of all exercise types when compared to the 2018 survey, but more exercises need to be done including the community level.

21 (96%) countries reported that their country's NTWC and/or TWFP participated in a Tsunami Drill (e.g. IOWave) conducted in the inter-sessional period (Figure 24). Mozambique reported that it did not participate.

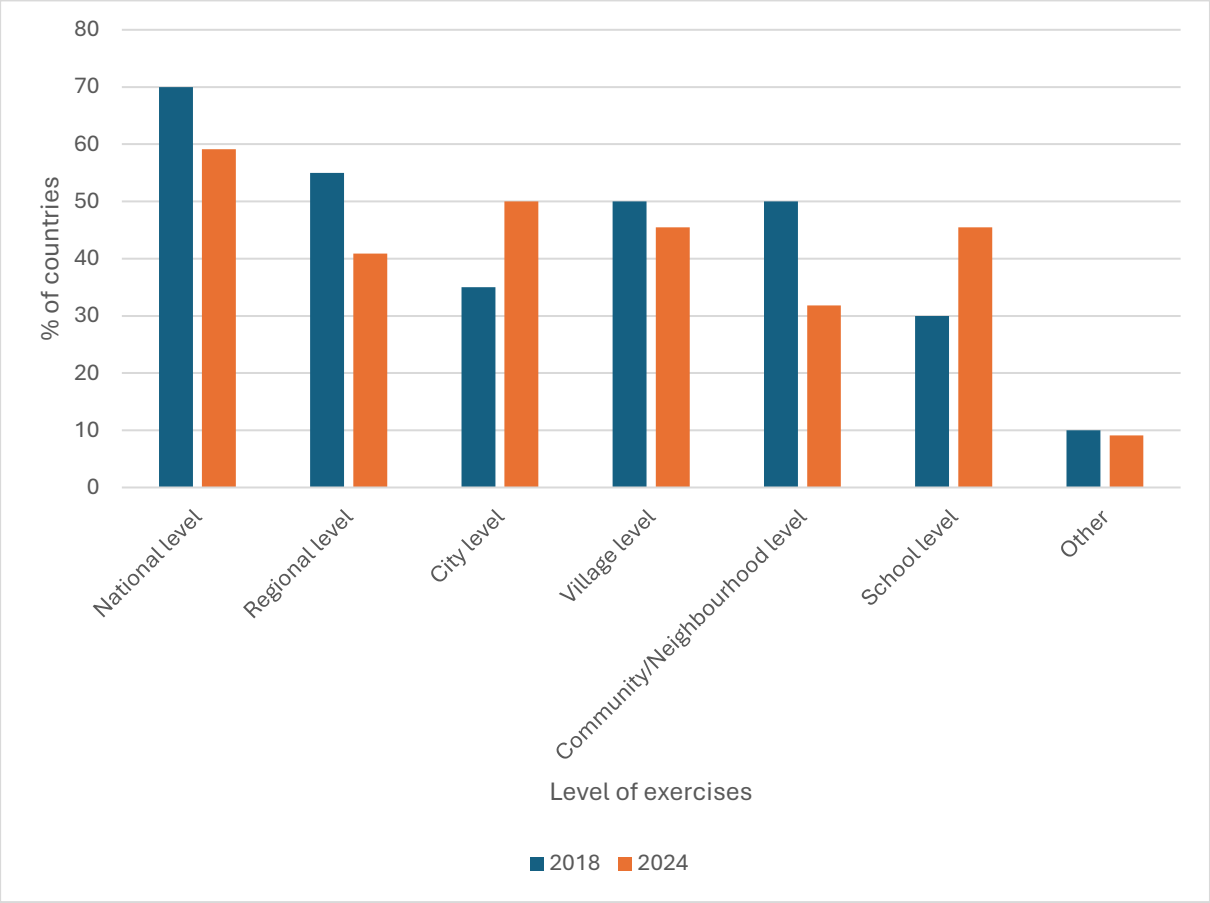


Figure 60: Levels of tsunami exercise conducted

Countries were also asked to report on their participation in communication tests and drills. 20 (91%) countries reported that their country's NTWC and/or formally designated Tsunami Warning Focal Point (TWFP) participated in the six-monthly communications tests conducted by the IOTWMS TSPs. France Indian Ocean Territories reported that it did not participate due to a lack of time.

In summary, Indian Ocean wide IOWave Exercises have been extremely successful in testing systems and community awareness. But these exercises need to involve more at the community level. More countries also need to implement national tsunami exercises, within a multi-hazard framework and especially down to the community level, to ensure their warning systems remain fit-for-purpose and ready to engage for any tsunami threat (Figure 62).

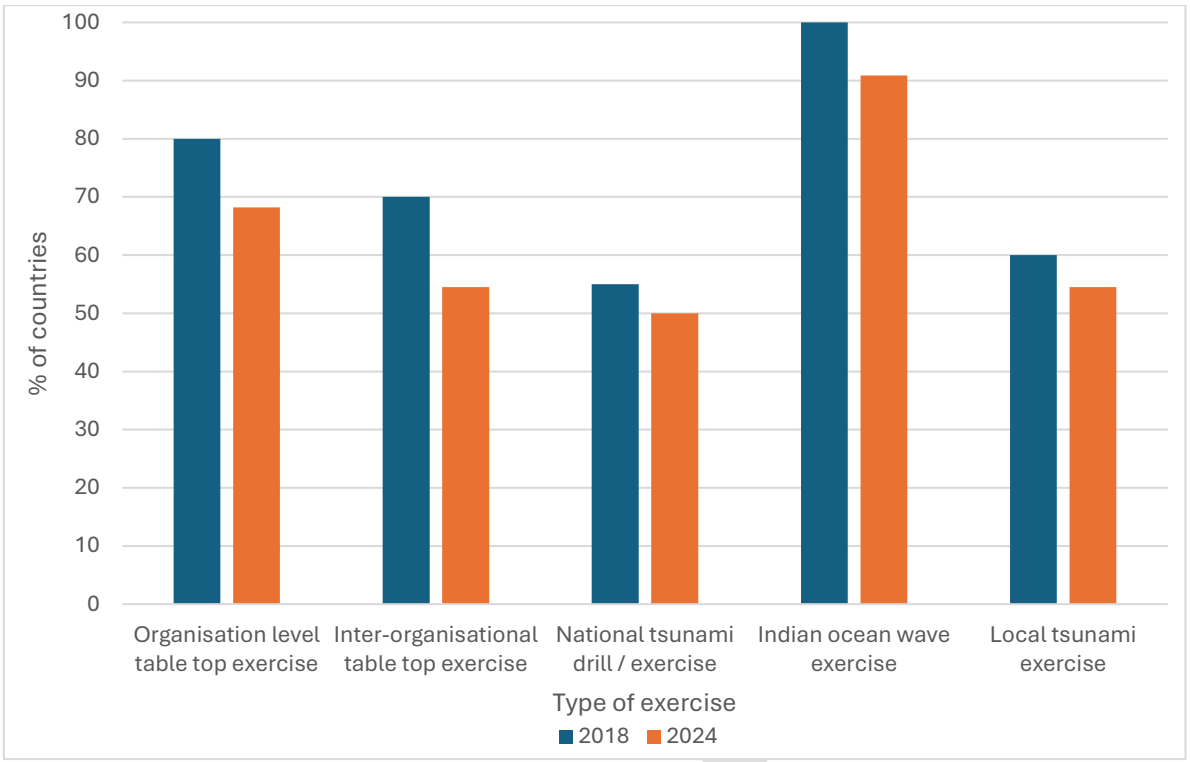


Figure 61: Types of tsunami exercise conducted

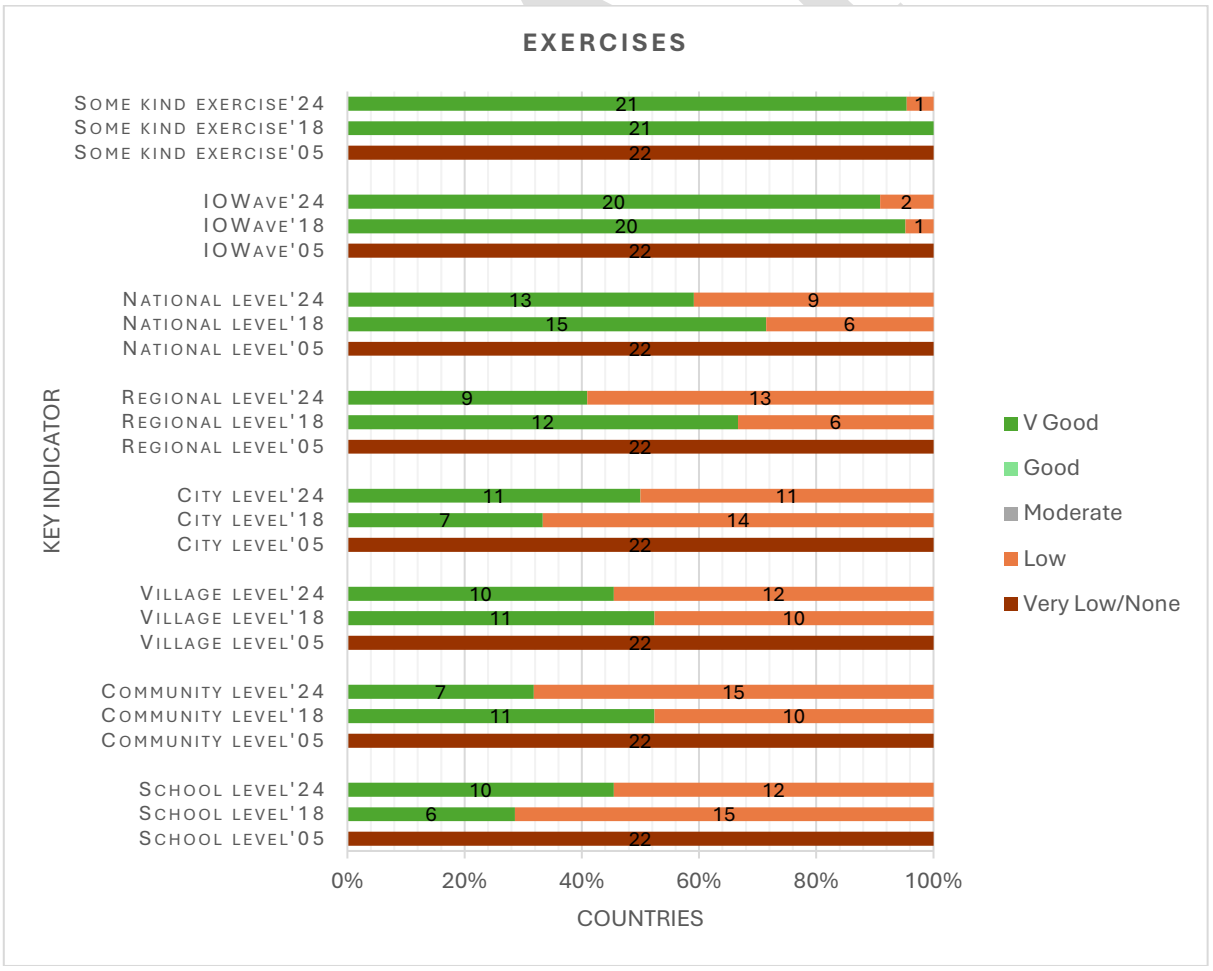


Figure 62: Country activity and capacity status for tsunami exercises.

CONCLUSIONS AND RECOMMENDATIONS

Significant progress was made between 2005 and 2018 to develop a robust, well-coordinated, and state-of-the-art regional tsunami threat information system and associated national tsunami warning systems. Unfortunately, between 2018 and 2024 progress has somewhat plateaued. Efforts have been gradually increasing with regards to preparedness at the community level, but this needs to be accelerated. Much more work needs to be done. The potential impacts of tsunamis are very challenging to prepare for, as they are a relatively low risk, but with major consequences and impacts should they occur. They may best be managed and supported through expansion of a multi-hazard approach, whereby observations, warning systems, community education and preparedness activities are integrated and contribute to multi-hazard national initiatives, noting the economies of scale and to ensure the tsunami threat remains centre of mind in well prepared at-risk communities, especially where the tsunami may arrive in minutes. It's also important to note that while some countries may have the capability, they don't necessarily have the capacity/resources to fully implement.

Just over 50% of hazard and risk assessments are currently under multi-hazard assessments for tsunamis generated by subduction zone earthquakes. But more hazard and risk assessments need to be undertaken at the local level within multi-hazard frameworks, and include tsunamis generated by non-seismic and complex sources. This will help provide better awareness to governments, response authorities, and the community on any possible threat. This in turn facilitates and provides purpose for the development of appropriate preparedness. More effort is required to make the more hazard and risk assessment data publicly available to increase awareness. Measures of uncertainties associated with all assessments are needed to better inform risk-based decisions. Country priorities for capacity development have been identified for hazard and inundation mapping, risk assessment at city level.

TSPs operated by Australia, India, and Indonesia provide detailed forecast threat information for the entire Indian Ocean to enable NTWCs to develop and disseminate warnings for their communities for tsunamis generated by earthquakes. However, only around 50% of available seismic and sea-level detection data is shared in real-time. To meet the goal of the UN Ocean Decade Tsunami Programme of more timely and accurate warnings for tsunamis generated by all sources (i.e. including non-seismic and complex sources) by 2030, capacity development through significant expansion of existing and implementation of new observing networks is required.

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After the fast implementation of an Interim Alert System (IAS) in 2005 to provide at least basic alerts to National Tsunami Warning Centres (NTWCs) established by all countries, since 2011 a well-coordinated and interoperable IOTWMS has been successfully established, continues to operate, and is routinely exercised. The ICG/IOTWMS designated Tsunami Service Providers (TSPs: operated by Australia, India, Indonesia) continue to provide the National Tsunami Warning Centres (NTWCs) (although two do not meet 24/7 requirement) in each country around the Indian Ocean with tsunami threat information for tsunamis generated by subduction earthquakes. One TSP (Australia) is now also providing regional threat information products for tsunamis generated by volcanoes. The NTWCs utilise the TSP products and in many cases also their own information to develop and disseminate appropriate tsunami warnings to their communities.

The interoperable system developed by the UNESCO-IOC ICG/IOTWMS is routinely tested and exercised through communication tests and IOWAVE Exercises organised by the ICG/IOTWMS and supported by the Secretariat (supported by the Government of Australia). More countries need to exercise at the community level. However, the accuracy and timeliness of the present threat information and associated warnings continue to be restricted and potentially compromised by the lack of around 50% of existing seismic and sea-level data being accessible in real-time. As recommended by the UN Ocean Decade Tsunami Programme, to further and greatly enhance the timeliness and accuracy of warnings to save more lives, for tsunamis generated by not only subduction earthquakes, but also by non-seismic and complex sources, requires implementation of an expanded network of observations, including better access to existing data and the use of new technologies to fill gaps in current network coverage.

Survey results and a forensic analysis of national tsunami warning chains of all countries indicates further effort is required nationally by some countries to ensure SOPs underpin every link in the warning chain,

especially in the downstream components, to ensure early warnings reach all in the community. Efforts to enhance national tsunami warning chains will also help underpin efforts by the UN EW4ALL initiative, as there are many common elements for other hazards. More countries need to implement national tsunami exercises, within a multi-hazard framework and down to the community level, to ensure their national warning chains remain fit-for-purpose and effective for any threat.

For a tsunami warning to be effective once it reaches all in the community, the community must be prepared and know what to do. To meet the goal of the UN Ocean Decade Tsunami Programme of 100% at-risk communities prepared and resilient to the tsunami threat by 2030, and while India and Indonesia have begun to initiate significant national programmes, further support is required to significantly enhance efforts to implement the UNESCO-IOC Tsunami Ready Recognition Programme or similar national initiatives across the region at the at-risk community level. The UNESCO-IOC IOTIC continues to provide vital training and community education and awareness materials. However, significantly more resources and support nationally are required for countries to implement national programmes at the community level. The challenges in implementing the UNESCO-IOC TRRP or similar national initiatives have been identified and countries need training and support to help address these.

The UNESCO-IOC IOTIC (funded by Indonesia) continues to be a great asset in providing provide training and development of community education and awareness materials. The UNESCO-IOC ICG/IOTWMS Secretariat (funded by Australia) continues to support the governance requirements of the ICG and provide great value in coordinating all the efforts and contributions to the IOTWMS of the Member States.

The *Ad Hoc* Team 2024 IOTWMS CATP has developed recommendations and key actions for capacity development to address the identified gaps and to help guide the work programmes of the ICG/IOTWMS and contributions by donors (Annex 1). Also included are some general recommendations with regards to the assessment.

This report should be read in conjunction with the Summary Report for Policy Makers, compiled by the UN Economic and Social Commission for Asia and the Pacific (ESCAP) in collaboration with UNESCO-IOC.

ACKNOWLEDGMENTS

The 2024 Capacity Assessment of Tsunami Preparedness in the Indian Ocean was an activity undertaken in 2024 by the UNESCO-IOC Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS), chaired by Prof Dwikorita Karnawati from Indonesia. An *Ad Hoc* Task Team2024 IOTWMS CATP was established under Working Group 3 Tsunami Ready Implementation to carry out the required work. Members of the Ad Hoc Task Team included: Ms Suci Anugrah (Chair, ICG/IOTWMS WG-3 Tsunami Ready Implementation) (Indonesia); Mr Ardito M. Kodijat (Head UNESCO-IOC Indian Ocean Tsunami Information Centre) (Indonesia); Ms Sunanda Manneela (Vice-Chair, ICG/IOTWMS RWG NW Indian Ocean) (India); Dr Yuelong Miao (Vice-Chair ICG/IOTWMS) (Australia); Dr Mohammad Mokhtari (Chair, ICG/IOTWMS RWG North-West Indian Ocean) (Norway); Mr Jijjavarapu Padmanabham (Chair, ICG/IOTWMS WG-2 Tsunami Detection, Warning and Dissemination) (India); Dr Harkunti Rahayu (Chair, ICG/IOTWMS WG-1 Tsunami Risk, Community Awareness and Preparedness) (Indonesia); and Ms Weniza (Chair ICG/IOTWMS Task Team Exercise IOWave23) (Indonesia). It included the contributions of invited experts: Prof Richard Haigh (University of Huddersfield) (UK); Prof Dilanthi Amaratunga (University of Huddersfield) (UK); and Mr Harald Spahn (Tsunami warning chain and evacuation planning expert) (Germany). Dr Laura Kong (UNESCO-IOC/NOAA International Tsunami Information Centre and ICG/PTWS representative) (USA) and Ms Lara Bland (ICG/PTWS representative) (New Zealand) provided perspectives from another ocean basin TWS.

Survey responses were received from 22 countries: Australia; Bangladesh; Comoros; France Indian Ocean Territories; India; Indonesia; Iran; Kenya; Madagascar; Malaysia; Maldives; Mauritius; Mozambique; Myanmar; Oman; Pakistan; Seychelles; Singapore; South Africa; Sri Lanka; Thailand; and United Arab

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Mr Rick Bailey (Tsunami expert consultant, former Chair ICG/IOTWMS, and former Head ICG/IOTWMS Secretariat) helped coordinate the work of the *Ad Hoc* Task Team 2024 IOTWMS CATP and compiled this Technical Summary Report and its Executive Summary. Ms Nora Gale (ICG/IOTWMS Secretariat) assisted with the survey review and distribution to countries. Mr Bernardo Aliaga from the UNESCO-IOC Secretariat provided general support to the work of the *Ad Hoc* Team 2024 IOTWMS CATP.

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ANNEX 1: Capacity Development Recommendations

#	*Warning & Mitigation System Attribute*
	Policies and Plans
TPP.1	Provide training in development of integrated national MHEWS and stand-alone tsunami policies and plans for authorities and stakeholders (such as DMOs, local governments, research institutions, communities, etc) across following levels: 1. National 2. Provincial 3. Local 4. Community
TPP.2	Provide training in development of specific tsunami guidelines in a multi-hazard framework with respect to: 1. Disaster Risk Reduction (DRR) based urban and spatial planning incorporating city/district level (scale 1:25,000) and detailed spatial plan for sub-district level (scale 1:5,000). 2. Contingency Plan for tsunami generated by multi-sources (seismic, non-seismic, and complex sources) 3. Operation Plan for tsunami generated by multi-sources (seismic, non-seismic, and complex sources) 4. Prevention and Mitigation: Tsunami Building Code, Critical Facilities Tsunami Ready Guide, Hotel Ready for Tsunami 5. Integration of tsunami DRR strategies into planning processes for mitigation and preparedness, e.g. zoning laws that prevent construction in tsunami high-risk areas and the development of tsunami-resistant infrastructure 6. Mainstreaming of inclusivity in all aspects of tsunami-related activities, policies, and plans, including scientific research, community education and preparedness, evacuation planning, and post-disaster management. 7. Sustainable grey and green coastal protection management practices that reduce vulnerability to tsunamis, such as nature-based solutions for the restoration of mangroves and coral reefs. 8. Rehabilitation and Reconstruction planning and Sustainable Recovery through lessons learnt to Build Back Better
TPP.3	Optimise national resources in tsunami preparedness and response planning, in areas such as tsunami hazard assessments, harmonisation of early warning systems, and joint exercises by: 1. Utilising cross-border tsunami warning and response coordination and planning for countries sharing coastlines (e.g. North-West Indian Ocean (NWIO)). 2. Exchange of best-practice policies, plans and guidelines for tsunami preparedness and response planning between Member States
	Tsunami Hazard and Risk Assessment
THRA.1	Help further raise awareness of Member States and at-risk communities of the Indian Ocean tsunami hazard by: 1. Utilising international expertise and collaboration to provide an updated best-practice Probabilistic Tsunami Hazard Assessment (PTHA) across the entire Indian Ocean, including tsunamis generated by non-seismic and complex sources 2. Develop tsunami hazard assessments for the Indian Ocean in a multi-hazard framework.
THRA.2	Enhance the national capacity to undertake tsunami hazard and risk assessments in a multi-hazard framework down to local level where required by: 1. Identification of national authorities responsible for undertaking tsunami hazard and risk assessments. 2. Identification of authorities to provide local level tsunami inundation maps to facilitate community preparedness initiatives. 3. Increasing the essential data available to undertake tsunami hazard assessments (e.g. bathymetry, topography) 4. Provision of training in national tsunami hazard assessment. 5. Provision of training in national inundation mapping for pilot areas to help identify communities at-risk 6. Collection of detailed tsunami risk data at village and community levels, especially information on vulnerable and inclusive groups, to better inform tsunami risk assessments 7. Provision of training in tsunami risk assessment

#	*Warning & Mitigation System Attribute*
	Tsunami Detection, Warning, and Dissemination
TDWD.1	Enhance the timeliness and accuracy of tsunami threat information and warnings by: 1. Designing the optimal seismic & sea level observing systems to guide implementation of observational networks to quantifiably improve the timeliness and accuracy of tsunami warnings 2. Sustaining, fully utilising, and expanding existing seismic and sea level observational networks to implement optimal observing systems to quantifiably improve the timeliness and accuracy of tsunami warnings 3. Trial and adopt new technologies (such as SMART cables, GNSS network) to implement optimal seismic and sea level observing systems to quantifiably improve the timeliness and accuracy of tsunami warnings 4. Demonstrating the impact of gaps in real-time exchange of seismic and sea level data on the timeliness and accuracy of tsunami detection and warning 5. Exchanging all data in real-time required for tsunami detection, warning, and monitoring by all National Tsunami Warning Centres (NTWCs) and regional Tsunami Service Providers (TSPs) to improve the timeliness and accuracy of tsunami detection and warning. 6. Establishing collaboration channels and training activities for sea level network operators to create awareness on needs for tsunami detection and warning to encourage expansion and sustainability of existing networks 7. Developing guidelines and delivering training on adoption and implementation of advanced analytical platforms that utilise artificial intelligence and machine learning to integrate and analyse data from multiple sources to enhance the accuracy of tsunami models and improve warning decision-making processes
TDWD.2	Enhance the capacity and effectiveness of National Tsunami Warning Centres (NTWCs) by: 1. Ensuring all NTWCs operate 24/7 2. Provision of human and infrastructure resources to support NTWC operation 3. Training for NTWCs in analysing and utilising real-time seismic and sea-level data and models to develop capacity to undertake own tsunami threat analysis 4. Develop capabilities & Standard Operating Procedures (SOPs) for detection, warning, and monitoring of tsunamis generated by non-seismic and complex sources (e.g. IOC M&G 183) 5. Developing tsunami warnings in a multi-hazard framework to optimise available resources
TDWD.3	Ensure People Centred national tsunami warnings reach all in the community by: 1. Ongoing forensic analysis and regular review of national tsunami warnings chains and underpinning SOPs to identify weak links and gaps 2. Providing ongoing training in national tsunami warning chain and SOP development to address weak links and gaps, facilitated by training Member States from geographical regions with similar tsunami threat and warning requirements (e.g. NWIO project funded by ESCAP), with particular focus on N/P/LDMO and Media SOPs. 3. Training in delivery of tsunami warnings using common terminologies and formats (e.g. Common Alerting Protocol (CAP)) to ensure more effective use and all-inclusive community responses. 4. Continuous reviewing of existing (internet, GTS, SMS, satellite, radio, fax, etc) and implementation of new (social media, cell broadcast, etc) tsunami warning dissemination and communication technologies to ensure robust and timely dissemination of tsunami warnings to all-inclusive groups in the community and communications between warning and response operational staff.
	Community Tsunami Awareness and Preparedness
TPAPR.1	Raise community awareness of tsunami threat by: 1. Sharing and utilising national and Indian Ocean Tsunami Information Centre (IOTIC) Information Education & Communication (IEC) tsunami awareness materials, materials used in other oceans and developed by other Tsunami Information Centres (TICs), nationally tailored materials for individual stakeholders, translated as needed at local level and all inclusive 2. Disseminating IEC tsunami awareness materials using a wide range of formats and platforms for dissemination (e.g. brochures/fliers, e-posters, booklets, e-books, YouTube, TikTok, Instagram, Facebook) 3. Participation/support by international agencies or experts in national activities 4. Utilising internationally coordinated activities, such as International Day for Disaster Risk Reduction (IDDRR) (13 October) and World Tsunami Awareness Day (WTAD) (5 November)

#	*Warning & Mitigation System Attribute*
TPAPR.2	Enhance national capacities in tsunami evacuation planning by: 1. Expanding training on tsunami evacuation planning provided in NWIO to other regions and Member States, including sharing of best practices through a hands-on and collaborative learning approach. 2. Providing regional training on best practices in utilising vertical infrastructure for tsunami evacuations. 3. Engaging professional societies and experts in national activities to advise best practices and certified national criteria for evaluating shelter options in the context of tsunami vertical evacuation strategies 4. Share examples of best practice in national tsunami signage, taking into consideration recommendations from the UNESCO-IOC TOWS-WG TTDMP.
TPAPR.3	Enhance tsunami awareness and preparedness in schools by: 1. Continuing the work of UNDP, in consultation with IOTIC, in the development of tsunami school community awareness IEC materials and training 2. Implementing tsunami awareness and preparedness training in school national curricula.
	Tsunami Ready Recognition
TRRP.1	Train, both regionally and nationally (with priority for Small Island Developing States (SIDS), Least Developed Countries (LDCs), and African State), the implementation of UNESCO-UNESCO-IOC Tsunami Ready Recognition Programme (TRRP) or similar national or international initiatives (e.g. Weather Ready) to build resilience and make at-risk communities prepared and resilient against the tsunami threat, by: 1. Supporting National Tsunami Ready Focal Points (TRFPs) and Tsunami National Contacts (TNCs) through training, advocacy and provision of IEC materials (e.g. UNESCO-IOC M&G 74 and IOTIC education and awareness materials), including translation to national and/or local languages where needed 2. Exchanging Member State best practices and experiences on initiating, implementing, and demonstrated value of TRRP to assist other Member States to initiate. 3. Assisting Member States to review their national tsunami preparedness programs with respect to the 12 Tsunami Ready Indicators.
TRRP.2	Implement and expand national Tsunami Ready Recognition Programmes (TRRP) or similar national initiatives to make at-risk communities prepared and resilient against the tsunami threat by: 1. Identifying tsunami risk and educate communities and key stakeholders of the risk and value of TRRP 2. Investigating if TRRP can be integrated within a similar national initiative or obtain seed funding to start the TRRP nationally (or an equivalence) to demonstrate value in a multi-hazard context. 3. Establishing a National Tsunami Ready Board (NTRB) as per IOC M&G 74 or utilise similar national body 4. Identifying and providing data on communities/villages in tsunami-prone areas (as described in M&G 74) to develop a prioritised plan for implementing TRRP nationally 5. National authority with responsibility for TRRP or similar national initiative collaborating with at-risk communities to create education materials tailored to their local context 6. Assuring local communities' ownership of TRRP or similar national initiatives by strengthening local capacities, engagement to develop local preparedness plans, activities in line with the TRRP indicators, and commitment to sustain it. 7. Engage the private sector to implement and help resource implementation 8. Engage Non-Government Organisations (NGOs) and other international agencies supporting national implementation 9. Integrating other ocean and multi-hazard approaches with the TRRP approach
	Tsunami Exercises
TE.1	Continue to organise and enhance biennial IOWave Exercises for the Indian Ocean region to routinely test regional and national tsunami preparedness by: 1. Including scenarios of nighttime and/or weekend tsunami events to test 24/7 procedures and performance. 2. Including an objective testing and validating of SOPs along national tsunami warning chains. 3. Avoiding times when DMOs, etc, are busy responding to other seasonal hazards, by scheduling two different times/seasons for biennial IOWave Exercises within scheduled year. 4. Nationally extending involvement at at-risk local and community levels. 5. Involving international expert observers to help review and evaluate future IOWave Exercises

#	*Warning & Mitigation System Attribute*
TE.2	Increase national tsunami exercises to more frequently test national tsunami preparedness by: 1. Establishing regular programme of tsunami exercises into cities, villages, communities and schools as a key to community preparedness, through conduct of national exercises between Indian Ocean-wide exercise (IOWave exercises) 2. In addition to IOC MG58 and MG86, developing further guidance on how to the conduct tabletop or similar tsunami warning exercises to routinely review and test SOPs, helping to maintain preparedness and reduce the potential for complacency among countries that have not experienced a recent tsunami event.