Mapping of IOC-UNESCO Tsunami Ready Indicators in the Pangandaran Village, Indonesia

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Abstract. Pangandaran Village is a tourist village located in Pangandaran Regency, West Java Province, Indonesia. The beautiful view of sand beaches and abundant marine resources make Pangandaran Village has great economic potential. However, in 2006, an earthquake with a magnitude of 7.7 Mw triggered a tsunami disaster in the Pangandaran area that caused more than 600 fatalities, injuries, and damage to buildings, especially in Pangandaran Village. Based on current research, there is potential for an 8.7 magnitude earthquake off the south coast of Java in the near future, triggering an enormous tsunami. The coastal community in Pangandaran Regency has been building a tsunami risk reduction strategy to anticipate the tsunami disaster. In Pangandaran Village, the local community is piloting the 12 tsunami ready indicators following the guideline from UNESCO-IOC. Therefore, this study aims to map 12 tsunami ready IOC-UNESCO indicators in Pangandaran Village to evaluate which indicators the government and community of Pangandaran Village. The method used in mapping 12 tsunami ready indicators in Pangandaran Village is to take data in the field by doing aerial photographs, conducting interviews with the village government and other related local stakeholders, mapping tsunami evacuation plan and infrastructure, and disseminating questionnaires to the community to find out the response to the tsunami disaster. Based on the IOC-UNESCO tsunami indicator mapping results, all indicators have been fulfilled. However, several other aspects of tsunami preparedness indicators still need to be improved to strengthen tsunami preparedness in Pangandaran.

1. Introduction
Pangandaran Village is one of the most prominent villages in the southern part of West Java Province. One of the potential tourist destinations that can attract many tourists is Pangandaran Beach [1]. Pangandaran is a large fishing village located on a narrow isthmus, with Pangandaran National Park encompassing the entire headland. Two long sweeping beaches of black volcanic sand can be found on either side of Pangandaran Village and the National Park isthmus. Pangandaran Beach has a lot to offer, including visits to the National Park, Green Canyon, Paradise Island, Pangandaran Waterpark, Batu Karas Beach, seafood markets, and local markets. Alternatively, tourists can relax and enjoy the views, the beaches, the friendly people, and the slow pace of this charming and friendly place [2].

However, despite its charm and beauty, Pangandaran Village is highly vulnerable to natural disasters such as tsunamis caused by an earthquake triggered by the subduction zone between Indo-
Australia Plate and Eurasian Plate. The Pangandaran Tsunami in 2006 was one of the most memorable events. The Pangandaran Tsunami struck following an earthquake on 17 July 2006, at 15:19:22 local time. The earthquake had a magnitude of 6.8 on the Richter scale or a magnitude of 7.7, with the epicenter located in the southern part of Java Island, roughly in the Indian Ocean at 9.46° South – 107.19° East [1]. Tsunami waves killed over 647 people, left 456 people missing, and destroyed 66 tourism facilities in Pangandaran. In addition, based on the National Center for Earthquake Studies (PuSGEN), the southern coast of West Java also has the potential for earthquakes with a magnitude of up to 8.7 from West Java and Central Java Megathrust [3], which of course has the potential to produce an enormous tsunami and a more severe impact. The tsunami's severe impact on tourism facilities, combined with a drop in tourist numbers, has prompted the United Nations World Tourism Organization (UNWTO) to assist tsunami-affected countries, particularly those in tourist areas.

Therefore, it is necessary to carry out reasonable mitigation efforts by setting up a system that can ensure the preparation of disaster-prone areas so that more lives can be saved. Preparations that need to be made include better planning, education, awareness, and emergency managers strengthening their local operations. In 2015, the UNESCO IOC Intergovernmental Coordination Group for Tsunamis and other Coastal Hazards for the Caribbean and Adjacent Regions (ICG/CARIBE EWS-X) recommended the approval of the Tsunami Ready Recognition guidelines, and this recommendation was approved by the IOC General Assembly [4]. To support current and future piloting of the IOC-UNESCO tsunami ready, UNESCO/IOC commissioned the review and analysis of the Tsunami Ready Guidelines (Draft Intergovernmental Oceanographic Commission Manuals and Guides no.74: Standard Guidelines for the Tsunami Ready Recognition Program). The Indian Ocean Tsunami Information Centre (IOTIC), in collaboration with the secretariat of the Indian Ocean Tsunami Warning and Mitigation System (ICG/ IOTWMS), has organized several workshops Piloting Tsunami Ready in the Indian Ocean. Invited experts from the Indian Ocean will highlight each of the IOC-UNESCO Tsunami Ready indicators and shared practical experience and examples of communities who have received the IOC-UNESCO Tsunami Ready Recognition [5].

In this study, the IOC-UNESCO Tsunami Ready Indicator mapping was carried out in Pangandaran Village to know the level of preparedness of Pangandaran Village for tsunami disasters that might occur at any time. These results will later be helpful for local governments, disaster agencies or BPBD, and local organizations or communities to prepare tsunami ready indicators that are still incomplete in the Pangandaran Village area.

2. Data and Methods

2.1. Data

In this study, the fulfillment of the IOC-UNESCO Tsunami Ready Indicator requires data collected in the field. Data collection to meet the tsunami ready indicator is carried out by collecting data in the Pangandaran Village government, Pangandaran Regional Disaster Management Agency (BPBD), and community organizations such as Pangandaran Village Community Preparedness Forum (FKDM Pangandaran Village). The data needed to fulfill the tsunami ready indicators include tsunami hazard maps, the population in tsunami-prone areas, tsunami evacuation maps, tsunami emergency operation plans, and other resources to reduce the tsunami's impact that refers to the standards set by the IOC-UNESCO.

2.2. Methods

This research was conducted in Pangandaran Village, Pangandaran District, Pangandaran Regency, West Java Province, Indonesia. The reason for choosing Pangandaran Village as the study area is because Pangandaran Village has significant economic resources related to the beauty of tourism and its fishing village. In addition, this area is also vulnerable to tsunami disasters. In 2006, the Pangandaran experienced a tsunami phenomenon which caused considerable damage and loss of life in this area. The map of the study area can be seen in Figure 1.
The method used in this study was to conduct interviews with the Pangandaran Village government, BPBD Pangandaran Regency, Pangandaran Village Community Preparedness Forum (FKDM), and the Pangandaran Regency Tourism Office. In addition, a field survey was conducted to determine the distribution of evacuation signs and tsunami disaster information boards and tsunami shelters in Pangandaran Village. This survey aims Tsunami Ready mapping was carried out using the standards set by IOC-UNESCO [5]. The field survey was carried out on 19-22 March 2021 by visiting the institutions mentioned above to collect data, conduct interviews, and conduct field visits to obtain data.

3. Results and Discussions
The IOC-UNESCO Tsunami Ready Indicator mapping is presented in the subsection below based on interviews, field surveys, and data processing.

3.1. Indicator 1: Have designated and mapped tsunami hazard zones
In indicator 1, tsunami-prone areas must have a tsunami hazard map. A tsunami hazard map can be obtained by conducting tsunami modeling. Windupranata et al. have carried out tsunami modeling in the southern region of West Java, showing that the Pangandaran Village area is at risk of being completely submerged, especially in residential areas with average inundation up to 6 meters [6].

Based on Figure 2, Pangandaran Village has the potential to be inundated entirely, especially with an immersion height of >3 m with an earthquake scenario from Megathrust West Java - Central Java with a Magnitude of up to 8.7. Based on modelling, the area not submerged in the Pangandaran Village area is in the Nature Reserve area, which has a hilly topography to the south of Pangandaran Village.
3.2. Indicator 2: To develop an initial estimate of the number of people that live in the tsunami hazard zone

Based on data obtained from the Pangandaran Village Office, it shows that the residents of Pangandaran Village have 11,247 residents consisting of 5,670 males and 5,577 females with a detailed age distribution can be seen in Table 2. In addition, there are also people with disabilities, namely 30 males and 14 females [7]. These numbers are residents who are prone to be exposed to the tsunami disaster.

Table 1. Number of residents of Pangandaran Village [7]

| Age  | Male  | Female |
|------|-------|--------|
| 0-4  | 369   | 352    |
| 5-9  | 441   | 351    |
| 10-14| 483   | 435    |
| 15-19| 473   | 446    |
| 20-24| 463   | 452    |
| 25-29| 463   | 458    |
| 30-34| 408   | 389    |
| 35-39| 407   | 431    |
| 40-44| 439   | 446    |
| 45-49| 400   | 405    |
| 50-54| 385   | 385    |
| 55-59| 346   | 353    |
| 60-64| 212   | 242    |
| >=65 | 374   | 419    |
| Total| 5,670 | 5,577  |
In addition, since the Pangandaran area is a tourist area, some tourists are potentially affected by the tsunami disaster. Based on data obtained from the Pangandaran Regency Tourism Office, before the COVID-19 pandemic, precisely from the data from 1 January 2018 to 1 March 2020, the average daily visitor to Pangandaran was 7,255 visitors, with the minimum daily visitors being 111 tourists and the most visitors being on 17 June 2018 as many as 114,410 tourists [8].

3.3. Indicator 3: Have a public display of tsunami information

Since the 2006 Pangandaran Tsunami, the government and the public have become aware of the tsunami disaster. After that, a public information facility about the tsunami was built using a tsunami hazard board and a sign for a tsunami evacuation route. An example of an installed information board and evacuation sign can be seen in Figure 3.

During the field survey on 19-22 March 2021, a road survey was carried out in Pangandaran Village to collect data related to tsunami evacuation signs matched with the BPBD Pangandaran Regency data. The results of the survey show that there are many tsunami evacuation signs in the Pangandaran Village area. However, at least 31 tsunami evacuation signs are wrong coordinate input or missing when matched with the BPBD Pangandaran Regency data. In addition, many signs and information boards have been damaged or not maintained and require repairs.

Other information obtained from the field survey is information boards for tsunami-prone areas released by the community because they feared it would scare visitors traveling to Pangandaran. To deal with such an incident should require more intensive education to the community to understand the purpose of posting the tsunami information.

![Tsunami Information Board](image1)

![Tsunami Evacuation Route Sign](image2)

Figure 3. Tsunami information in Pangandaran Village (a). Tsunami information board (b). Tsunami evacuation route sign

3.4. Indicator 4: Develop an inventory of available economic, infrastructural, political, and social resources to reduce tsunami risk at the community level

Indicator 4 describes an inventory of economic, infrastructure, political and social resources related to reducing the risk of a tsunami disaster. Based on interviews conducted in the field survey, it is known that the Pangandaran Village Government with village funds has budgeted specifically for tsunami disaster management. Although the nominal of the budget is not explicitly stated.

Infrastructure resources prepared for tsunami risk reduction include preparing several points for temporary evacuation sites in the Pangandaran Village area and its surroundings. In Pangandaran Village itself, a Nature Reserve area is agreed to be used as an evacuation site in a tsunami disaster. In
the border area of Pangandaran Village and Pananjung Village, a 5-story tsunami evacuation shelter was also built for tsunami evacuation. In addition, there are seven hotels designated as evacuation sites in Pangandaran Village, considering the large number of tourists visiting the Pangandaran area.

Regarding political resources, Pangandaran Village already has special regulations or standards related to the evacuation process or emergency response in the event of a tsunami listed in the Surat Keputusan Kepala Desa or Decree Pangandaran Village Head Number: 144/47-Kpts/Desa/2020 [9].

On the other hand, Pangandaran Village has a very active preparedness organization represented by the FKDM Pangandaran Village. FKDM Pangandaran Village and BPBD Pangandaran Regency organize disaster education activities and prepare activities regarding disaster preparedness in the Pangandaran village area. Together with FKDM Pangandaran, other organizations such as Civil Defense (LINMAS), the Fisherman's Community, and the Tourism Entrepreneurs Community in Pangandaran village supports disaster risk reduction, especially the tsunami disaster.

3.5. Indicator 5: Produce easily understood tsunami evacuation maps as determined to be appropriate by local authorities in collaboration with communities

Pangandaran Village is generally known as a village that is prone to tsunami disasters. So many tsunami evacuation maps have been made for Pangandaran Village, as shown in Figure 4. These tsunami evacuation maps were made by different agencies, including National Disaster Management Agency (BNPB), BPBD, and Meteorological, Climatological, and Geophysical Agency (BMKG). The differences in tsunami evacuation maps also indicate differences in the information presented, especially in the detail of information and the purpose of a tsunami evacuation.

![Figure 4. Tsunami Evacuation Map in Pangandaran Village](image-url)
In Figure 4(b), for example, the direction of the evacuation route looks more straightforward and is only found on certain roads compared to other maps. In addition, different things can also be seen in Figure 4(c), which makes the hotel in Pangandaran Village an evacuation destination, which is different from other evacuation maps that immediate evacuation in nature reserves, tsunami shelters, and the Pangandaran Grand Mosque. Several versions of this evacuation map should be corrected to uniform the information to be presented so that the public, especially tourists who have just arrived in Pangandaran, can know the place and direction of tsunami evacuation to avoid confusion.

3.6. **Indicator 6: Development and distribution of outreach and public education materials**

The development and distribution of tsunami education materials in Pangandaran Village were carried out specifically by the BPBD Pangandaran Regency in collaboration with the Pangandaran Village FKDM. The development of educational materials is in the Wisata Edukasi Bencana Goes To School (GTS) program [12], which provides education to schools in the Pangandaran area in general (Figure 5). The distribution of this educational material is in the form of socialization to elementary-junior-high school students to provide knowledge and awareness of disasters in general. In addition, the BMKG also has tsunami disaster education materials called BMKG Pocket Book [13] that are made and can be applied in other areas that can be used for education about the tsunami disaster.

![Image of Wisata Edukasi Bencana Goes To School](image)

**Figure 5.** Goes to school program implemented by BPBD Pangandaran [12] and BMKG Pocket Book [13] as education materials related to tsunami disasters.

3.7. **Indicator 7: Hold at least three outreach or education activities annually**

The Pangandaran area always holds education and disaster preparedness activities regularly, which are carried out annually. This annual activity was initiated by the BPBD Pangandaran Regency together with the Pangandaran Village FKDM. The routine activities are Disaster Preparedness Day on 26 April and Commemorating the Pangandaran Tsunami on 17 July. In addition, the BPBD Pangandaran Regency also holds a Wisata Edukasi Bencana Goes to School (GTS) activity, as mentioned in the previous point, which targets school students to cultivate knowledge and awareness from an early age. Besides these routine activities, in Pangandaran, there were educational, and preparedness activities for the IOWAVE take in 2016, and the Geophysics Field School (SLG) in 2020 held by BMKG and BNPB, and the DESTANA expedition in 2019 held by BNPB.
Figure 6. Tsunami evacuation drill and socialization of the tsunami disaster from BPBD Pangandaran Regency [14]

3.8. **Indicator 8: Conduct a biennial tsunami community exercise**

As in indicator 7, the Pangandaran area, especially Pangandaran Village, routinely carries out tsunami training activities specifically for the community and local organizations such as FKDM.

3.9. **Indicator 9: Have a tsunami Emergency Operations Plan (EOP) for the community**

Pangandaran Village has prepared an Emergency Response Plan (EOP) document which is supported by a Surat Keputusan Kepala Desa or Decree Pangandaran Village Head Number: 144/47-Kpts/Desa/2020 [9]. The document contains tsunami hazard map, evacuation map, population data, emergency contact, list of disaster preparedness teams, Standard Operating Procedure (SOP) for tsunami early warning (Figure 7).

Figure 7. Flow chart used during the tsunami incident in Pangandaran Village [9]
3.10. **Indicator 10: Have the capacity to manage emergency response operations during a tsunami**

Pangandaran Village disaster preparedness team consisting of FKDM and LINMAS coordinated to respond to disaster events such as earthquakes and tsunamis. Then the emergency response decision is delivered through social media to be informed to the public. In addition, Pangandaran Village also has a Command Center and dissemination devices such as CCTV to monitor tsunamis, sirens, and loudspeakers that can be used to disseminate information on tsunami emergency response operations. The Command Center is located at the Pangandaran Village Office, connected to dissemination devices spread across the East Coast, West Coast, Tourism Market, and the Pangandaran Village Office. These supporting facilities can be seen in Figure 8.

![Figure 8. Supporting facilities for the emergency response operation during the tsunami disaster in Pangandaran Village](image)

3.11. **Indicator 11: Have redundant and reliable means to receive 24-hour official tsunami alerts**

Pangandaran Village can receive information about a tsunami hazard for 24 hours through several communication media, including:

- Social media between agencies such as BMKG, BPBD, Village Government, and FKDM.
- Through information disseminated by BMKG via SMS or Website.
- Via the Warning Receiver System (Figure 9)

Based on the information received above, all rely on electricity and internet network connections, while if an emergency occurs, electricity and internet connection may be cut off due to infrastructure damage caused by the earthquake. Therefore, alternative media should be prepared for receiving tsunami hazard information such as a radiotelephone.

![Figure 9. BMKG Warning Receiver System WRS](image)
3.12. Indicator 12: Have redundant and reliable means to disseminate 24-hour official tsunami alerts to the public

Pangandaran village also has communication facilities to disseminate earthquake information and tsunami early warnings to the Pangandaran village community. The communication media used include:

- Handy Talkie
- Social Media
- Speakers and sirens on the command center dissemination tool
- Tsunami siren at Telkom Pangandaran Building

Same as indicator 11, most of the media used use electricity and require an internet connection. It is better to prepare traditional communication media such as bamboo clappers or "kentongan" and bells to warn residents of a tsunami disaster.

The experience of Pangandaran Village against the tsunami disaster in 2006, which is relatively new made Pangandaran area has excellent tsunami disaster preparedness because stakeholders have prepared it. Overall, the readiness of the Pangandaran village to the tsunami disaster can be seen in the fulfillment of the IOC-UNESCO tsunami ready indicator above Pangandaran Village, which was able to meet all of IOC-UNESCO tsunami ready indicators. Although some indicators still need some improvement, it can be said that these indicators have been met for the time being. After all, it is still in the preparation stage. However, improvements must always be made in terms of mitigation, preparation, and response to the tsunami disaster to reduce the impact of the tsunami disaster if it occurs later.

4. Conclusions

Based on the tsunami indicator mapping results read by IOC-UNESCO above, Pangandaran Village has fulfilled all the Tsunami Ready Indicators. However, it takes commitment and maintenance of disaster preparedness assets by the Pangandaran Village Community. In addition, it is necessary to add several alternative options because reliable resources are still very dependent on electrical instruments and internet connections. It is mainly related to receiving and delivering disaster early warning information to overcome the possibility of not having internet or electricity access, while during an emergency, internet and electricity connections may be cut off.

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