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Article

## Governance, Institutions and People within the Interface of a Tsunami Early Warning System

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### Abstract

The interface mechanism in a tsunami early warning system (TEWS) occurs between receiving tsunami information at the country level and disseminating warning and evacuation orders to the public. Three crucial actions take place during the interface: issuing the warning, disseminating it, and ordering an evacuation. Using two case studies in Indonesia and Sri Lanka, a study was undertaken to understand the nature of the interface mechanism and the social, cultural and political dynamics of its operationalisation. In this article, a comparative analysis of the two case studies is presented, focusing on the role of governance, institutions and people in this interface. The nature of governance, hierarchies and structures influence the interface mechanism and the associated decision-making mechanisms. The institutions who act as key stakeholders are also shaped by the governance structures and hierarchies within it. The efficiency of the institutions is determined by the nature of their human resources and are affected by political factors. The communities are also affected by the overall governance structure, the political dynamics and the institutional factors. The complex relationships between governance, institutions and officers that exist in the two countries affect the communities in different ways. Yet, the overall governance and institutional dynamics of TEWSs lead to a common thread of decisions and actions when operationalising the interface. The results are presented in a framework that illustrates the complex relationships between governance, institutions, officers and communities. The framework provides a basis for future research on how the interface of TEWS can be operationalised to effectively protect communities at risk from tsunami.

### Keywords

disaster dynamics; governance; Indonesia; institutions; interface; Sri Lanka; tsunami warning system

### Issue

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### 1. Introduction

The 2004 Indian Ocean Tsunami (IOT) is recorded as one of the deadliest disasters resulting from a natural haz-

ard since 1900. As a result, governments and international stakeholders in the region established the IOT warning and mitigation system (IOTWMS), which became fully operational in 2013 (UNESCO, 2013).

It was originally understood that there are two main mechanisms within a tsunami early warning system (TEWS), upstream and downstream (de León, Bogardi, Dannenmann, & Basher, 2006). However, in a recent study, an interface mechanism between the upstream and downstream was identified, whereby the tsunami warning decision is taken at the country level, the warning information is disseminated, and an evacuation order is issued (Sakalasuriya, Amaratunga, Haigh, & Hettige, 2018). There is very limited research that focuses specifically on the interface mechanism, as it is a relatively new term within the early warning field. They also found there to be an inadequate understanding of the interface mechanism among policy makers and practitioners in the early warning sector. The complexity within the interface mechanism and the related technical, social, political and administrative challenges, offer a narrative that will be useful in both scientific and practical circles. A study was undertaken to explore and understand the nature of interface mechanism of TEWS, and to offer guidelines to better its operationalisation. This article presents the findings of this study as a cross case analysis.

The two countries selected for this study are Indonesia and Sri Lanka, which are both member states of the common regional warning system, the IOTWMS. Among several countries affected by the 2004 IOT, Indonesia was the worst hit in terms of deaths and disappearances (NOAA, 2019a). Indonesia continues to be affected by tsunamis and earthquakes, due to its tectonic setting, and several tsunamis have affected the country since the 2004 IOT (NOAA, 2019b). In contrast, the 2004 IOT is the only tsunami to have impacted Sri Lanka in its recent history, but the 2004 event resulted in the highest recorded deaths by a single natural hazard in Sri Lanka (Jayasuriya, Steele, & Weerakoon, 2006). The two countries are different in terms of geographic and demographic features, and therefore the extent of (de)centralisation of the warning system also differs considerably. The beginning and end points of tsunami interface mechanisms in the two countries are also different (Haigh et al., 2020; Rahayu, Haigh, Amaratunga, & Sakalasuriya, 2019). However, both are developing countries and similar in terms of multilevel administrative structures and have diverse populations with social and cultural complexities. These different contexts shape the interface operationalisation, while also providing an opportunity to explore similarities. In this article, a comparative analysis of the two case studies is presented, focusing on the role of governance and institutions, and the people within those institutions.

## 2. Literature Review

### 2.1. Tsunami Early Warning System

A TEWS's main objective is to alert the communities living in exposed coastal areas about the upcoming danger and provide guidance for evacuation (Cecioni et al., 2014;

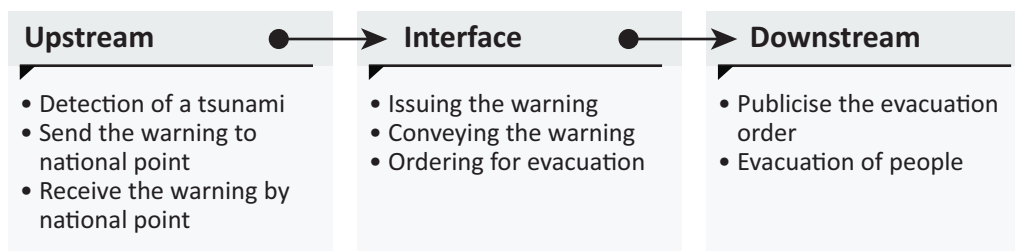
IOC & UNESCO, 2009). Several institutions that specialise in technical and managerial aspects of disaster preparedness work together to provide tsunami information to the public (UNIDDR, 2002). A speedy and accurate prediction mechanism, strong and consistent communication, and coherency and reliability, are some of the requirements (Basher, 2006; Cecioni et al., 2014; Perry & Green, 1982). Typically, a TEWS starts with the detection of an earthquake, goes through the steps of warning and evacuation, and ends with the safe return of people to their homes (de León et al., 2006). However, as has been highlighted by recent events in Indonesia, they can also be generated on impact as a rapidly moving landslide mass enters the water, for example following a volcanic eruption or underwater landslide.

### 2.2. The Interface of the TEWS

The upstream and downstream of warning systems are generally well defined and documented in official technical documents and previous studies (IOC & UNDRR, 2019; Usl , 2015; W chter et al., 2012). The upstream mechanism usually starts at the regional level, where an earthquake is detected, and the risk of a tsunami is forecasted. Once the warning information is received by a national authority, warning information is processed and disseminated within the country. The downstream mechanism is where the warning information and evacuation order is disseminated to the relevant authorities and general public, and if necessary, communities are relocated. Typically, the downstream mechanism continues until the risk of the tsunami is alleviated (Bernard & Titov, 2015; IOC & UNESCO, 2009). The interface in the context of TEWS is a relatively new concept and was not well defined in previous research. Recently, it has been identified as the series of actions that takes place between the upstream and downstream mechanisms. As highlighted in Figure 1, there are three significant action points: issuing the warning, conveying the warning and giving the order of evacuation (Sakalasuriya et al., 2018). This definition of interface was the underlying supposition used in directing the research. It was presented and validated at several focus group discussions (FGDs) held throughout the study.

### 2.3. Conceptual Framework Used for the Study

Based on the interface definition developed by the authors, a literature review was undertaken in order to understand the state of the art related to TEWS and establish a basis for data collection and analysis (Sakalasuriya et al., 2018). This literature review led the authors to construct a conceptual framework that consists of nine components. This framework was used as the foundation for data collection in both countries, as well as the analysis and reporting of the results. The nine components in the framework are: decision-making mechanism; clearly defined actors; centralised



**Figure 1.** The position of interface within the end-to-end TEWS. Source: Authors' composition, based on Sakalasuriya et al. (2018).

vs decentralised approach; standardisation of interface; technical capacity; human capacity; spatial and socio-cultural aspects; vertical and horizontal coordination; and, formal and informal communication mechanisms. For this article, these were further mapped into literature related to disaster governance and politics, as summarised below.

#### 2.4. Conceptual Framework for Interface of TEWS

All crucial action points within interface of TEWS—issuing the warning, conveying the warning and issuing the order of evacuation—involve decision-making by organisations and individuals (Sakalasuriya et al., 2018). It can be argued that the other eight concepts within the framework operate at the periphery of the decision-making mechanism. Governance on the other hand, is how a country or the state manages its resources to meet a certain objective, and it involves the interactions of stakeholders with each other to make decisions related to complex processes and outcomes (Cheema, 1997; Renn, 2008; World Bank, 1992). Governance is a key part of disaster risk reduction (DRR), both at the overarching policy level and within individual warning systems (Ahrens & Rudolph, 2006). DRR is a holistic, ongoing and systematic process and involves cross-border collaborations and governance arrangements between international, national and local stakeholders (Fakhrudin & Chivakidakarn, 2014; Tierney, 2012).

Van Niekerk (2015) defines disaster risk governance as the manner in which public entities, civil servants, media, and civil society coordinate, manage and reduce the risk of disasters. Modern disaster governance efforts are increasingly participatory, and address contracting and outsourcing, and public-private collaboration. These are replacing hierarchical and bureaucratic approaches (Tierney, 2012). Disaster risk governance occurs at all stages of a disaster: preventing, preparing to respond, managing the occurrence, and providing relief and recovery (Briceño, 2015; Fidler, 2005; Van Niekerk, 2015). The governance methods and structures across these stages may vary (Tierney, 2012). Early warning fits within the preparedness and management cycles of disaster risk governance. There are four main elements of early warning: risk knowledge; technical monitoring and warning service; dissemination and communication

of warnings; and response capability and preparedness (UNIDDR, 2002). A study by Spahn, Hoppe, Vidiarina, and Usdianto (2010) claims that well-developed governance and institutional arrangements are the foundations on which the above elements can be achieved. At the same time, effective disaster governance requires other attributes of good governance such as accountability, empowerment, deliberation, participation and representation (Lebel et al., 2006).

Disaster governance is built within the overarching governance system that already exists in society (Tierney, 2012). Fakhrudin and Chivakidakarn (2014) add that the disaster governance structure of a country should be based on the national disaster management institutional structure, and that effective early warning relies on the policies, laws, institutional frameworks, and the capacities of the officers. For the purpose of this study, the governance structure/system is defined as the institutional arrangement and hierarchy, legal frameworks and the political stimuluses that support the establishment and maintenance of TEWS.

The institutional arrangements established to reduce disaster risk and vulnerabilities, and to address the challenges after a disaster, form a significant part of disaster risk governance, and integrated and multisectoral disaster risk assessments require committed and knowledgeable institutional stakeholders at all levels (Tierney, 2012). On the other hand, multi-layered and polycentric institutional arrangements are key in developing disaster risk efforts under good governance (Lebel et al., 2006). It is also necessary to clarify the roles and responsibilities (Spahn et al., 2010).

The institutions that operate within early warning systems must be specialised in their tasks on identifying, assessing and managing the disaster risk, and be able to influence the other development stakeholders (Briceño, 2015). At the same time, it is important to maintain resource capacities internally and coordinate with other stakeholders (Spahn et al., 2010). Sakalasuriya et al. (2018) highlight that vertical and horizontal coordination among the stakeholders is a key factor that determines the effectiveness of an early warning system. Gaps in coordination can result in errors and misunderstandings (Haigh et al., 2020; Rahayu et al., 2019). Within an early warning system, the institutions should build trusting relationships with other stakeholders by under-

standing the duties and responsibilities of each other (Samaratunge, Coghill, & Herath, 2008).

According to Ahrens and Rudolph (2006), accountability, participation, predictability and transparency are the key features of an effective disaster governance structure that supports DRR. Participation is also a key factor that contributes to building trust and accountability within the governance structure, and ensures equal distribution of benefits and risks (Lebel et al., 2006). According to Koliba, Mills, and Zia (2011), trust allows people to take decisions without having complete knowledge or information about the issue on which they are taking decisions. Trust is usually built through strong written agreements, correct decision-making procedures and through negotiations. Uhr and Ekman (2008) defines trust as the “relation between a trustor and a trustee where the expected behaviour and competence of the trustee in a specific context, estimated by the trustor, is a central core in the concept.” For the purpose of this study, trust is defined by the authors as the ability of the communities and organisations to promptly follow the guidelines given to them in a tsunami warning situation, without further questioning the authenticity of the system.

Implementation of effective disaster governance systems and establishment of early warning institutional arrangements requires strong political leadership and commitment (Spahn et al., 2010). Samaratunge et al. (2008) claim that political interests and agendas are a key factor that affect the disaster risk governance framework and its operation. Policy oriented interventions, backed by strong political will and commitment, can help to grow institutional and community resilience to disasters (Pelling, 2011). In this study, political influence refers to the actions and decisions taken by national and local level politicians or groups of politicians in power that affect the TEWS.

Based on the above analysis, the following concepts have been derived to form a conceptual framework related to governance, institutions and people within the interface of TEWS: 1) Decision making within disaster governance structure; 2) institutional arrangements—hierarchy, functions, standardisation, interinstitutional coordination, and human resources; 3) community participation and trust; 4) political influence. These are used as the basis for analysing the data and reporting the results.

### 3. Methodology

The conceptual framework mentioned in Section 2.3 was used as the underpinning guideline for developing the data collection and analysis tools for the study. The data collection process was oriented towards gathering information from both countries to be measured against the conceptual framework. However, semi structured key informant interviews (KIIs) and FGDs were used as an opportunity to explore beyond the conceptual framework and allow additional concepts, themes and areas of

analysis to be discovered. Sri Lanka and Indonesia were selected as the two case studies. Three research teams were involved in the study: a coordinating research team in United Kingdom, and country teams in Indonesia and Sri Lanka, further described in the Supplementary File (Annex 2). The research design and data collection protocols were subject to the ethical approval procedures of the affiliated universities of the authors. A FGD was held in each country for validation purposes. Further details of the in-country data collection and validation processes are given in the Supplementary File (Annex 3). Separate reports were prepared based on the findings in each country.

The cross-case analysis presented in this article was led by the UK research team, based on the country reports, and was reviewed by the Indonesian and Sri Lankan partners. The comparative analysis focused on the governance systems and institutions related to the TEWSs. It was based on the conceptual framework presented in Section 2.4. According to Khan and VanWynsberghe (2008), new research knowledge can be produced by mobilising and accumulating the case data, and comparing and contrasting the cases. Comparison of case studies can help the researchers to incite imagination, ask new questions, construct new dimensions and think of alternative realities (Stretton, 2013). Ragin (2004) and Khan and VanWynsberghe (2008) suggest two approaches for carrying out cross-case analysis: variable-oriented and case-oriented. Due to the limited time frame and differences in research teams, the variable-oriented approach could not be used for the cross-case analysis in this article. Thus, the case-oriented cross-case analysis is used to derive the generalisations presented in this article, by comparing the commonalities and variances between the two cases.

## 4. Results of the Cross-Case Analysis

### 4.1. Institutional Arrangements

In this section, the nature of the interface institutions in the TEWS are discussed, focusing on their hierarchy, functions, standardisation and coordination with each other.

#### 4.1.1. The Hierarchy

It is revealed through this study that the institutions that operate within a TEWS are established within and adapted according to the existing governance structure of the country. Their hierarchy, functionality, standards and relationships to other institutions are shaped by the governance system within which they operate. Within the interface, the key national and local stakeholders mainly consist of government institutions or individuals attached to and representing those institutions.

In Sri Lanka (hereafter SL-TEWS), all significant interface institutions operate at national level; namely Department of Meteorology (DoM), Disaster

Management Centre (DMC) and Ministry of Disaster Management (MDM). On the other hand, in Indonesia (hereafter Ina-TEWS) both national and local stakeholder institutions make decisions during the interface, including Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG), Indonesian National Board for Disaster Management (BNPB), Local Disaster Management Organisation (BPBD), and the local mayor's office. Within Ina-TEWS, there is clear hierarchy from BMKG as information provider and decision maker to other actors who disseminate information and issue evacuation orders. In Sri Lanka, while the ministry has the highest constitutional authority, DoM and DMC acts as agencies under the ministry, performing critical roles within the interface. Although the DoM is directly regulated under the MDM, it is difficult to determine the line ministry of the DMC, as evidence suggests links to MDM, the Ministry of Defence, as well as to the Office of the President (DMC, 2020a, 2020b; MDM, 2009, 2019; MOF, 2014). It is also difficult to distinguish between DMC and DoM based on hierarchy, as both are national level institutions directly related to the Ministries, and both play significant roles in disaster warning and management.

#### 4.1.2. Functions of the Institutions

The IOTWMS (IOC & UNDRR, 2019) identifies several key functions at the regional and national levels. The Tsunami Service Providers (TSPs) of Australia, India and Indonesia work as a "system of systems," generating tsunami forecast information products simultaneously to all Indian Ocean coastal areas. The TSPs make tsunami forecast information products available to the Tsunami Warning Focal Points (TWFPs) of each country, which operate 24/7. It is the responsibility of the National Tsunami Warning Centre (NTWC), who may also be the TWFP, to evaluate the tsunami information provided by the TSPs, decide on appropriate national action and issue tsunami warning instructions to their public. The National Disaster Management Offices (NDMOs) should play a key role in taking efficient and immediate actions to ensure public safety before, during, and after the event. The relevant organisation for each of the above functions for each country are summarised in the Table 1.

#### 4.1.3. Standardisation

Standard operating procedures (SOPs) are the guidelines agreed upon by the stakeholders to determine who, what, when, where and how (United Nations ESCAP, n.d.).

In Sri Lanka, SOPs are prepared by institutions such as MDM, DMC and DoM for their internal use. Some general guidelines on early warning and emergency response situations are available in the National emergency operation plan (NEOP) which is prepared by the DMC (DMC, 2015). However, it was evident from the interviews and desk study that SOPs of different institutions are not formally integrated. The absence of a common guideline that can be followed by all stakeholders has created a lack of understanding among the individuals within the institutions, which was demonstrated during the FGD conducted during the data collection stage. For example, officers from DoM and DMC had disputes regarding 'who contacts the regional TSP and the ministry' and 'who takes the final warning decision.' Both claimed these responsibilities. Ministry representatives were also not able to clarify. It became evident that the communication mechanism among these officers was based on personal relationships. After the initial analysis stages of this study, an integrated SOP was developed by the key stakeholders. This integrated SOP was tested during the 2018 Indian ocean-wide tsunami (IOWave) exercise, and was further improved and later adopted (Amaratunga, Haigh, & Dias, 2019; Haigh & Amaratunga, 2018).

The Service Guidebook for Ina-TEWS is the principal document prepared to guide all the stakeholders within the Ina-TEWS. This includes guidance for national and local stakeholders, the public and private sectors (BMKG, 2012). In addition, there are guidelines available within the individual institutions, both at national and local levels. It was revealed that the guidelines can be specific to local circumstances. However, several gaps were identified. For example, the roles of BNPB, EOC and BPBD were not specified as key warning conveyors and decision-makers in the regulations. In practise their roles are significant in terms of information dissemination and in activating local evacuation orders. There are also gaps in the clarity of the guidelines given in the service guidebook. For example, under the regulations, the primary role of EOC, BNPB and BPBD is described as activating the relief funds, and their roles within warning and evacuation are not highlighted. In practise these three institutions play a significant role in disseminating warning and evacuation information.

#### 4.1.4. Inter-Institutional Coordination

The interface institutions are crucial stakeholders that contribute to the effective operation of the TEWS. In Sri Lanka, DoM is required to collaborate with DMC,

**Table 1.** Functions of the national institutions within TEWS.

Function	Ina-TEWS	SL-TEWS
Regulator	BMKG	MDM
NTWC/TWFP	BMKG	DoM
NDMO	BNPB	DMC

Source: Authors' composition based on data analysis.



GSMB and NARA. However, the DoM does not recognise the need to formally liaise with the GSMB, as the GSMB can only provide earthquake information and not tsunami updates. At the same time, NARA can only provide sea level monitoring services, and their information is not adequate for advanced tsunami risk identification. Due to the lack of coordination among the institutions and absence of a synergised SOP, misunderstandings have occurred among the stakeholders.

In Indonesia, coordination among the national actors was described as adequate and effective by the interview participants. For example, there is internal horizontal coordination and communication among divisions in BNPB; i.e., EOC, PUSDATIN (Data and Information Centre) and PASTIGANA (Center For Disaster Alert Situation Analysis). In an early warning situation, EOC provides situation information to the board of director, PUSDATIN and PASTIGANA. Through press conferences and press release, PUSDATIN of BNPB gives clear information about a disaster event and its impacts to mass media and public community. Meanwhile PASTIGANA make situation analysis reports using maps and graphic information. However, problems were identified in terms of coordination between national and local actors, as well as among the different local stakeholders within the city or region. The coordination between BNPB and BPBD was found to be inadequate, due to the misunderstandings of the warning command chain. At the same time, the different local BPBDs were found to have their own mechanisms and guidelines for giving the order of evacuation, resulting in discrepancies between local evacuation efforts.

#### 4.2. Decision Making within the Governance Structure

The main tasks that take place within the interface of TEWS are issuing the warning, conveying the warning and issuing the order of evacuation. In both Indonesia and Sri Lanka, the interface starts once the warning from regional TSPs is received at the national level. The crucial decisions of issuing the official tsunami warning and order for evacuation take place either at the national or the local level based on the country situation.

##### 4.2.1. Issuing the Warning

The information received from other TSPs is processed within BMKG to determine the level of tsunami risk, and the decision to issue the warning is taken by the BMKG (a detailed explanation of decision making within BMKG is given in the Supplementary File (Annex 3). The warnings are issued at the national level at this point, both by BMKG and BNPB. The decision to issue the warning typically takes place within five minutes of receiving regional information.

In the case of Sri Lanka, the earthquake and tsunami information are received by DoM. However, unlike Indonesia, the national level tsunami impact is not evalu-

ated at the country level in Sri Lanka due to limited capabilities, but they maintain the links with technical institutions to determine changes in the tsunami threat level. The decision to issue the tsunami warning is taken by DoM based on the technical information they receive. The criteria for taking this decision is further explained in the Supplementary File (Annex 4).

##### 4.2.2. Conveying the Warning

In Indonesia, once BMKG decides to issue a tsunami warning, the national level warnings and guidance for evacuation are issued by the BNPB, the national disaster management agency. The warning and evacuation information is communicated to all the national and local level interface institutions. At the national level this includes the Ministry of Home Affairs, police and military, and the Ministry of Communication, Information and Technology. The warning and evacuation information is also disseminated to local level governments and local disaster management centres. The dissemination of warning and ordering for evacuation at local level may take different durations based on local circumstances. The warning information and evacuation guidance are also broadcast through television and radio networks, and the official social media channels of BMKG and BNPB.

In SL-TEWS, DoM sends the tsunami bulletins to DMC, who then communicates the warnings, and if appropriate, evacuation orders to all the other national and local stakeholders. According to the information revealed through the FGD in Sri Lanka, the process of determining the tsunami threat, disseminating to the DMC and deciding on order of evacuation takes place within less than half an hour. This mainly takes place through telephone or mobile conversations. While the official warning chain takes place between the regional TSP, DoM and DMC, it is the responsibility of the DMC to inform the Ministry of the potential threat of tsunami through which the relevant minister and the president are also kept in the communication chain. It was revealed at the FGD that the Director General of DMC directly informs the Secretary or an Additional Secretary of the Ministry through telephone about the risk. The interface institutions and the ministry maintain personal contacts with each other until the tsunami threat is alleviated.

##### 4.2.3. Issuing the Evacuation Order

In Indonesia, the local governments are bestowed with the responsibility of issuing the evacuation order at regional and city levels. Mayors have the official responsibility of announcing the order for evacuation. During the study it was revealed that the mayors are given clear guidelines on issuing evacuation orders and supported by the local level trained officers who have more knowledge. At the same time, there are alternative arrangements to take decisions by local EOCs or BMKG in case the mayor is absent.

In Sri Lanka, evacuation decisions are taken by the DMC on behalf of the MDM and the government. The evacuation orders are transferred to the national media and local governments for action. In contrast to Indonesia, the interface warning and evacuation chain in Sri Lanka is contained within the national level. The evacuation orders are issued through the national television and radio networks, as well as through official social media accounts of interface institutions.

A common factor within the interface of both countries is that political actors maintain a high influence in the decision-making mechanism. The MDM in Sri Lanka needs to agree with the warning and evacuation decisions before they are disseminated. The local mayors in Indonesia are issuing the official evacuation orders at regional and city levels. A main difference between the two countries is decentralisation of the interface mechanism in Indonesia. Although decentralisation of disaster governance has sometimes been advocated, it is not advisable to do so in the absence of adequate capacity (see Section 2.4). The large physical land area and approximately 6,000 populated islands, as well as a decentralised government structure, provides a rationale for having local decision-making mechanisms in Indonesia. However, the involvement of local level governance within Ina-TEWS requires rapid action and decision making, and is often criticised in previous studies (Chatfield & Brajawidagda, 2013; Seng, 2013; Spahn et al., 2010). During the tsunami event caused by 2018 Sulawesi earthquake, it was reported in the media that local authorities did not have adequate time to enact the local orders, and there was a large human death toll (BBC, 2018). Efficiency and speed are significant in the case of Ina-TEWS due to the nearfield threat faced by some communities. This raises questions over the decision to mandate local governments with the responsibility for issuing evacuation orders, but is, at least in part, a legacy of the decision in 2000 to decentralise government to regencies and municipalities.

#### *4.3. Human Resources: People within the Institutions*

Two major individuals involved in the interface of SL-TEWS are the Minister and the Secretary to the Minister. In case of an emergency and warning issuance, both DMC and DoM inform the Secretary about the changing developments, who then updates the Minister. Being a political representative and a member of the cabinet, the Minister also keeps the President and other relevant Ministers informed about the situation. As the national disaster management institution, the individuals in DMC are under direct scrutiny and well-connected to political actors. However, gaps were identified in relation to human capacity in some of the interface institutions. For example, NARA is not able to maintain and deliver sea level data to DoM as it does not operate 24/7.

DoM faces issues with its human resources due to the heavy workload and staff being stretched into several

responsibilities. Some individuals in the disaster management sector of Sri Lanka have also developed a passiveness towards a potential tsunami. Some of the officers who participated in interviews and FGD displayed a lack of knowledge of the up-to-date procedures and international bulletins. The officers who participated in official region-wide training provided for member states of IOTWMS have failed to report their learnings and updated information back to their institutions. For example, at the March 2018 FGD it was revealed that the tsunami bulletins practised within SL-TEWS have not been updated according to international standards since 2012.

The Director General of BMKG, Indonesia, is the head of BMKG. An inspector and a main secretary are two main leads under the Director General, and the rest of the staff function under their guidance. Like DMC in Sri Lanka, BNPB is under the direct supervision of the President of the Republic of Indonesia, and there are several secretaries and deputy heads that function under the head of the BNPB. However, the roles played by individuals within Ina-TEWS institutions tend to adapt and change depending on the situational circumstances. For example, in the March 2016 event, BNPB did not have a critical position in the tsunami early warning sequences, but rather on the emergency response with the EOCs in activating the emergency fund (Coordinator and Joint Event Assessment Team, personal communication, 2017). Limitations in human capacity were also identified in relation to interpreting information on tsunami warning and using equipment and tools (FGD and documentary evidence). Some local level actors failed to activate the warnings during tsunami events due to a lack of understanding of the warning bulletins, and the corresponding procedures for actions. The local mayor is a key individual within the local operation of Ina-TEWS. Since the mayor is a political actor, EOC specialists are essential in supporting the mayor and these personnel require training and effective leadership skills to determine an evacuation order in the absence of the mayor. Despite these concerns, training, knowledge of bulletins and standards were maintained and updated according to international standards. This pro-active approach, in contrast to Sri Lanka, is likely due to the more recent experiences of tsunami, and the higher levels of tsunami exposure and frequency.

#### *4.4. Community Participation and Trust*

The ultimate objective of a TEWS is to take people to safety during the tsunami inundation (IOC & UNESCO, 2009). It is important to maintain a positive relationship between the TEWS governance structure and the communities. The institutions in both countries have recognised the importance of raising community awareness and education through preparedness activities, drills and simulation exercises. The region wide IOWave tsunami exercises are carried out once every two years and additional education programmes are implemented by DMC



in Sri Lanka and BMKG in Indonesia (desk study and interviews). Since Sri Lanka has not faced a tsunami since the establishment of the SL-TEWS, the only measure of community response considered for this study are the drills and simulation exercises. It was revealed during the FGD in Sri Lanka, that the community issues that arise during the simulation exercises were rarely reported to the top level, making it difficult to update the evacuation procedures. The observation report from 2018 IOWave exercise suggests that there is a need to improve community participation in more areas, as well as include participation of vulnerable communities in the evacuation drills (Amaratunga et al., 2019). Unlike Sri Lanka, Indonesia has faced several tsunami events since the establishments of Ina-TEWS, allowing lessons to be learnt. The desk study revealed that the community deaths in 2012 and 2016 tsunamis were caused by technical and/or human errors in the systems rather than a lack of community preparedness. The destruction caused by the 2018 Sulawesi earthquake was also due to unpredicted rapidity of the tsunami impact (Heidarzadeh, Muhari, & Wijanarto, 2019), rather than weaknesses in community preparedness.

At the same time, the trustworthiness and credibility of the government and the government institutions affect the emergency response of the community (Uhr & Ekman, 2008; Wray, Rivers, Jupka, & Clements, 2006). The historical experiences of misinformation have led people to panic in the absence of tsunamis in both countries, as well as not evacuate in actual tsunami events in Indonesia. For example, a false warning was issued in Sri Lanka on 11 April 2012 causing people to panic and lives were lost due to road accidents. During the 2018 Sulawesi tsunami, there was no official tsunami warning delivered to the people due to technical failures, causing large scale loss of lives and destruction (Harnantaryi et al., 2020). This emphasises not only the responsibility of the government to improve technical accuracy, but also the need for institutions to work with the communities at risk and the local leaders to raise awareness.

#### 4.5. Political Influence

The involvement of political actors is understood to be an issue in both cases, but at different levels. As discussed in Section 4.2.2, assigning the responsibility for activating an evacuation order to a local political actor, who is also not a specialist in any warning procedures, can be problematic. This delegation of authority is due to a much wider decision to decentralise government and give greater authority, political power to regencies and municipalities, rather than to optimise early warning. While it is important to involve public figures in TEWSs to increase community preparedness, it has the potential to cause errors within the warning chain, where promptness of delivery and accuracy of information are critical.

Along with active participation of officers, political leadership and willingness are also necessary to reverse this trend and increase awareness and attentive-

ness among vulnerable communities. Political interventions in government institutions—appointments, transfers and personal relationships—can also be related to the passiveness of the officers. The transferring of trained staff in DMC and DoM to other government institutions was found to be problematic, as the training underwent by the transferred staff is wasted and the newly recruited personnel must be trained again to fit the requirements of the institutions. The political involvement in appointments and transfers of the government sector employees is a common issue in Sri Lanka (Höglund & Piyarathne, 2009; McCourt, 2000, 2007). However, when those influences take place in key sectors like disaster management, the safety the public will be ultimately at risk. This can also result in the institutions being run by unskilled and apathetic officials. It is necessary to allow the management of human resources within interface institutions to take place without political intervention, and based on merit, specialisation and skills. Rather than influencing the inside mechanisms of the institutions, the politicians have a wider role to play in terms of representing the interests of the community within the government as well as bringing the crucial messages of the government to the community.

#### 5. Discussion and Conclusion

The findings of this study suggest that the complex relationships within the governance structure—the decision-making mechanism, institutional arrangements and political influence—can have a profound influence on the community responses in a TEWS. The interface is an important stage within the early warning process, as the rapidity and accuracy of decision-making and information dissemination determine the safety of the communities.

Table 2 is a summary of the findings and gaps (gaps are in highlighted text), and a set of recommendations that can be adopted to address the gaps. These were presented to the relevant agencies in each country.

Based on the analysis presented in this article, a framework was been developed to summarise the findings of the article (Figure 2). This framework highlights the relationships between governance, institutions, officers and communities within the interface of TEWS, and was developed to reflect the learnings from the two case studies.

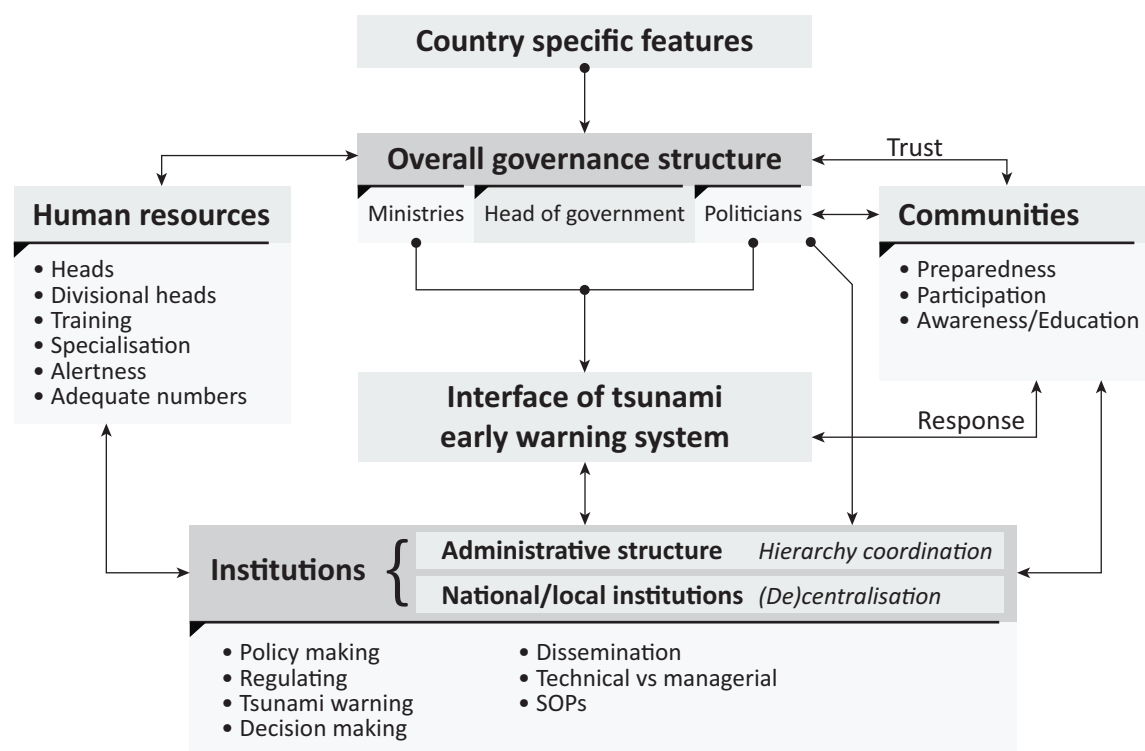
The TEWS is established within the existing governance structure, and the interface is a mechanism that takes place within the TEWS that involves three key actions: issuing the warning; conveying the warning; and ordering for evacuation. The institutions pertaining to interface of TEWS are operating under the legal and administrative frameworks provided in the governance system.

Depending on the nature of existing governance structure, the interface can either be centrally operating at a national level or decentralised to national

**Table 2.** Summary of findings/gaps and recommendations.

Concept	Indonesia	Sri Lanka	Recommendations
Decision making	Local mayor issuing the evacuation order* Partially decentralised	Personal contact with ministry to agree on decision* Centralised	Clear guideline to political actors on decision making Providing technical stakeholders with SOPs on level of political engagement
Institutional hierarchy	BMKG is the regulator and the warning provider Clear hierarchy at national and local levels	Absence of hierarchy between DoM and DMC Overarching authority of MDM	
Functions of the institutions	Different practices at local level* A political actor; local government, is involved in key task of issuing order of evacuation*	Both DMC and DoM engage in warning dissemination Both DMC and DoM maintains contacts with external service providers*	Specify roles of each institution Minimise discrepancies in practices among same-level institutions
Standardisation	SOPs for local circumstances Some discrepancies*	Absence of an integrated SOP for all stakeholders*	Establish SOPs within institutions as well as for overall TEWS
Interinstitutional coordination	Inadequate between BNPB and BPBD Lack of coordination between local stakeholders*	Mandatory coordination between DoM and NARA, GSMB not taking place due to lack of capacity*	Increase capacity and tools for coordination Provide SOPs on coordination and communication
Human resources	Changing roles according to circumstances Misinterpretations of bulletins and SOPs* Inadequate training and capacity at local level*	High individual involvement of ministry level actors Lack of capacity in training, specialisation and numbers* Transfers and new appointments* Lack of knowledge and passive behaviour*	Clearly identify roles of each officer within the institutions Mandate to appoint and retain trained and specialised staff Increase funding to human resource development
Participation and trust	Several tsunamis have occurred after establishing Ina-TEWS Misinformation/lack of communication causing deaths and affecting trust*	SL-TEWS has never been subject to an actual tsunami False warnings affecting trust* Lack of feedback from drills and simulation exercises* Inadequate participation in exercises* Negligence and indifference*	Improve TEWS through research/development Establish alternative means of communication in the failure of main warning chain Establish clear mechanism to receive feedback during simulation exercises Increase community participation
Political influence	Local mayor is not an expert in the field	Political influence on transfers/appointments within institutions* Lack of political vigilance to potential tsunami threat*	Minimise political influence within the institutions Technical and field experts without political influence Political leadership to increase awareness Use political influence to increase funding, improve capacities

Note: \* Summary of the gaps.



**Figure 2.** The framework on relationships between governance, institutions and community within the interface of the TEWS. Source: Authors' composition.

and local level institutions. The hierarchy, functions, level of standardisation and the inter-institutional coordination determine the effectiveness of these interface institutions. The roles and functions of institutions are mainly those related to policy making, regulating, taking warning decisions, disseminating the warning information, and giving and disseminating evacuation orders. The institutions can contribute to the interface in one or more areas of specialisation including technical, managerial, communication and facilitation. Officers within institutions are key in their successful operation.

While the officers are bound to work within the legal frameworks and regulations provided under the governance system, personal relationships to individual actors within the government structure are also important within the context of TEWS and can affect the maintenance of standards. On the other hand, the political actors within the governance system have a direct influence on the institutional operations as well as on the actions of the officers. Communities at risk are directly affected by the actions of officers, institutional operations as well as decisions of individuals within the government. The community response to TEWS is formed through preparedness, participation and education. These can be developed under the guidance of the governance system and using the resources within the institutions. The communities relate back to the governance system based on their past experiences of safety during the disasters and authenticity of the information provided the TEWS. For the governments to continue providing safety to the public, it is important that communities can trust the

TEWS and the related governance system, and that they can rely on the information provided by the institutions.

The framework presented in Figure 2 is at its conceptual stage, as it was developed specifically using the analysis of this article and based on the findings from Indonesia and Sri Lanka. Future research is required to further validate it and explore its applicability in different technical, social, political and administrative contexts. A more broadly tested framework could be used as a guideline for better understanding complexity within the interface mechanism and overcoming related governance challenges in TEWS.

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## Conflict of Interests

The authors declare no conflict of interests.

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