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Tsunami preparedness within Sri Lanka's education system

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ABSTRACT

Asked what hazard posed the greatest threat to their school, the principals of coastal schools in the Galle, Ampara and Batticaloa districts of Sri Lanka overwhelmingly responded *"tsunami"*. This result is unsurprising considering the scale and trauma caused by the December 26, 2004 Indian Ocean tsunami. This tsunami claimed over 35,000 victims in Sri Lanka, a third of whom were children. It damaged and destroyed 182 schools, and a further 287 served as camps for internally displaced persons. Given that Sri Lanka is far from all potential sources of earthquake-induced tsunami, and that there is time for early warning and evacuation, it is crucial that coastal schools are prepared and ready to act. This study uses semi-structured interviews with school principals and regional education and disaster management officials to gain insights into the tsunami preparedness of the Sri Lankan education sector. Overall, our findings show that schools are heavily reliant on tsunami early warning towers for their warning, yet only half of the 430 Sri Lankan schools exposed to tsunami are within audible range of a tsunami early warning tower. It is crucial therefore that alternative and backup early warning channels are established where needed. However, the interviews show that there is a very low level of baseline hazard preparedness. There are few or no fire drills, let alone tsunami evacuation plans or drills. The school principals express the view clearly that the education system in Sri Lanka is ill-prepared for a future tsunami. We find however that there are opportunities to involve existing safety committees in school preparedness and in the development of evacuation plans; and to exploit existing regular teacher curriculum training events to develop capacities in emergency response and evacuation. Importantly, experiences from a past tsunami drill with Sri Lankan communities emphasise the importance of holding regular school practice drills as well as "end-to-end" (from tsunami detection to tsunami evacuation) community evacuation exercises.

1. Introduction

Inclusive and resilient education services are a pillar of educational and societal development. Moreover, functioning educational services are critical to community post-disaster recovery and educational continuity [1,2]. Several global initiatives have recognised the important role played by schools and education in the process of recovery. As one of its global targets, the *Sendai Framework for Disaster Risk Reduction* (DRR) has the aim of reducing disaster damage and increasing the resilience of critical infrastructure, includ-

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ing health and educational facilities [3]. Similarly, the *Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector* (GADRRRES, 2017) advocates the strengthening of physical assets and governance against hazards, and supports disaster preparedness for improved school resilience. The *Comprehensive School Safety Framework* (CSSF) however, is broader in its approach and advocates the following three pillars to assist the reduction of risks to education (UNISDR & Global Alliance for Disaster Risk Reduction & Resilience in the Education Sector, 2017):

- **Pillar 1:** Safe Learning Facilities
- **Pillar 2:** School Disaster Management
- **Pillar 3:** Risk Reduction and Resilience Education

This paper focuses on Pillars 2 and 3. However, while the assessment of Pillar 1, *Safe Learning Facilities*, is not an objective of this paper, it is worth highlighting that school buildings in Sri Lanka typically have an elevated level of fragility to tsunami inundation [38]. The CSSF Pillar 2 encourages the development of national and sub-national contingency plans to support educational continuity, a central aspect of which is to limit the use of schools as temporary shelters to reduce disruptions to the provision. Pillar 2 also advises the establishment of coordination links between education and disaster management sectors. Lastly, it advocates the adoption of standard operating procedures such as the evacuation to safe havens and regular school-wide and community-linked practice drills.

Pillar 3 also emphasises the integration of risk reduction information and activities within schools, communities, and curricula. Other initiatives, such as the *Worldwide Initiative for Safe Schools* (WISS) and the World Bank's *Global Program for Safer Schools* (GPSS), support the implementation of the CSSF framework through political commitments and government-led partnerships [4]. However, the adoption of these principles in practice is still in its infancy in most developing countries.

This study aims to gauge the level of tsunami preparedness and disaster management capacity of the Sri Lankan school network. The first section of the paper provides an overview of school education in Sri Lanka and of the impacts on the education system of the 2004 Indian Ocean tsunami. The second section describes the current state of school exposure to tsunami in Sri Lanka and the tsunami risk and disaster management structures within the education system. The third section presents the findings of two sets of semi-structured interviews, one with 25 school principals and the other with officers from 8 education and disaster management authorities. In the concluding discussion, the authors identify key areas in which school tsunami preparedness can be improved.

2. Overview of the education system in Sri Lanka and past tsunami experience

The Ministry of Education (MoE) funds and manages the Sri Lankan system of general education at the national level, in unison with the nine provincial Ministries and Departments of Education. The MoE sets policies on a range of education matters. The National Institute of Education (NIE) establishes the curriculum for school students and teacher education. The Department of Publications produces school textbooks, and the Department of Examinations conducts public examinations. The Provincial Ministries and Departments of Education function within this national institutional framework and recruit and pay teachers. The system and the curriculum are organised around four stages of education: primary (Grades 1–5; age 5 + to 9 +); junior secondary (Grades 6–9); age 10 + to 13 +), senior secondary (Grades 10–11; age 14 + to 15 +) and collegiate (Grades 12–13; age 16 + to 17 +). By law, general education is compulsory up to Grade 11 and is fee-free up to Grade 13.

Sri Lanka has made excellent progress in promoting access to, and participation in, primary and secondary education. The 2017 net enrolment rate (NER) for primary education was 99%, for junior secondary education 84%, and for senior secondary and collegiate level education 70% (grades 10–13) [5]. These rates are high when compared with other lower middle-income countries [6]. Gender parity in primary and secondary education is also high, especially when compared with other lower middle-income countries. The NER at primary is 99% for girls and 98% for boys; and at junior secondary education it is 85% for girls and 84% for boys. The objectives of the CSSF are thus paramount for safeguarding the progress made within the education sector against the threat of disasters.

Hazard and disaster education is taught to primary level students (Grades 1–5) through the subject ‘environmental studies’; and at the secondary level (Grades 6–13) through geography, the sciences, citizenship education, and practical technical skills. The NIE prepares syllabi, teacher handbooks and workbooks for younger children. It trains teacher trainers and subject directors located in the provinces, who in turn train the teachers in the provinces through in-service training. This training supplements what teachers have learned during their pre-service teacher training and keeps teachers up to date with curriculum content and method changes.

2.1. Impact of the 2004 Indian Ocean tsunami on the education system

The Sunday December 26, 2004 mega thrust subduction earthquake of moment magnitude 9.1–9.3, in which the Burma plate thrust over the Indian plate across a 1200 km rupture, occurred near northern Sumatra at 06:58:53 Sri Lanka time (00:58:53 GMT). The resulting tsunami struck the eastern coast of Sri Lanka at 8:35 [7]. There was no early warning system at the time, and the tsunami caught most people on the coast unaware and unprepared. For example, many people did not recognize the retreat of the sea as an indication of the tsunami arrival, and ran towards the sea, rather than evacuating inland [8].

The tsunami inundation claimed 35,000 victims, (a third of whom were children), and injured a further 23,000. The tsunami destroyed upwards of 100,000 homes, initially displacing one million people. Its impact on Sri Lanka's education system was severe. Around 80,350 students and 3300 teachers were displaced from their schools across 10 districts. UNICEF [9] reported that the tsunami orphaned 932 children, and 3477 children suffered the loss of one parent. It is not clear whether the impact of the tsunami would have been greater or less if it had occurred on a regular school day. The tsunami affected 5% of Sri Lanka's schools, destroying 74 schools and severely damaging a further 108 [10]. Fig. 1 depicts damaged and destroyed schools as circles, with size indicating student population, and those that served as Internally Displaced Person (IDP) camps as triangles. Overlaid are the estimated inunda-

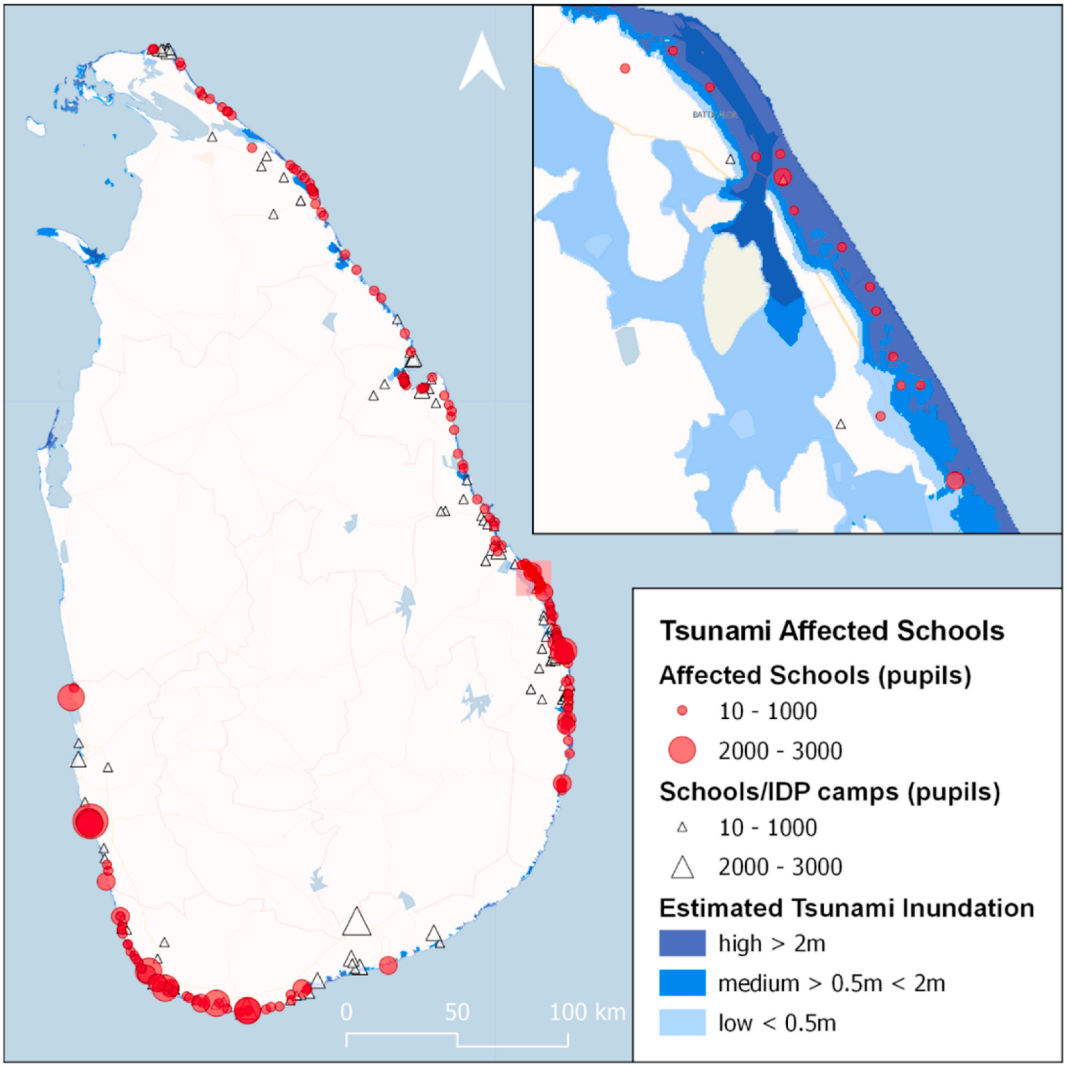

Fig. 1. Estimated 2004 tsunami inundation levels and destroyed/damaged schools (circles) and schools used as IDP camps (triangles); enlarged window of the Batticaloa district. Data from the Coastal Research and Design Division of the Coast Conservation and Coastal Resource Management Department; and Disaster Management Centre Sri Lanka (2012); and TERM The Education Rehabilitation Monitor [10].

tion zones of the 2004 Indian Ocean tsunami, which also form the basis of the current Sri Lanka Disaster Management Centre's (DMC) tsunami hazard profile [11,12].

The tsunami was not the only calamity that the education system had to contend with in 2004. Heavy monsoon floods had displaced 250,000 people only weeks before the tsunami in the Central, Eastern, and Northern regions. Moreover, the Eastern and Northern Provinces, which were the most heavily tsunami-affected regions (103 damaged and destroyed schools were in the Eastern Province), were also beset by a protracted conflict between the Liberation Tigers of Tamil Eelam (LTTE) and the Government of Sri Lanka (GoSL). Issues with security and child protection resulting from the ongoing conflict hindered school recovery in these areas [9].

Despite the magnitude of the challenges facing the education system, remarkably, most tsunami affected schools resumed classes in the third week of January 2005, and 85% of affected students were in learning environments by the end of March 2005 [9]. Overall, school enrolment rates recovered within the first year from the disaster, and overall drop-out rates were low. By April 2005 all affected schools functioned either through temporary school facilities or by transferring students to inland schools, with the latter adopting double shift arrangements to manage overcrowding [9,13]. A multitude of non-governmental organisations (NGO) and donor agencies helped to rebuild and rehabilitate affected schools, most of which were completed within two years [10].

2.2. School reconstruction and the current state of school exposure to tsunami

During the reconstruction phase after the 2004 Indian Ocean tsunami, the Ministry of Education (MoE) and others sought to reduce school tsunami risk. They did so by setting up a buffer zone of 100-m from the coast (200-m in the worst affected North and

East), to discourage schools from rebuilding in the same hazard-prone locations and relocate further inland instead. However, the relocation policy largely failed. Most schools did not relocate outside this buffer zone due to cost, difficulties with land procurement, and resistance from local communities, who opposed moving schools away from their livelihoods [10,13]. As a result, the buffer zone was reduced back to the previous local setback distances specified by the Coast Conservation Department based on coastal erosion, varying between 35 and 120 m from the Mean High-Water Line [14].

Another important development was that schools, NGOs, and local authorities mostly used a set of established architectural designs (from pre-tsunami times) for the reconstructed schools, to speed up the approval process [13]. Consequently, most schools were reconstructed in the same hazard-prone locations, and without adopting additional measures to improve their tsunami performance.

An investigation into current levels of school exposure indicates that there are 430 coastal schools in Sri Lanka that lie within the DMC's map of tsunami inundation [15]. This means that a future tsunami could potentially affect over 193,000 pupils [16]. This highlights the importance of the CSSF's Pillars 2 and 3 in reducing tsunami risk to schools and the education system in the Sri Lankan context.

2.3. Current tsunami risk and disaster management structures within the Sri Lankan education system

Sri Lanka remains highly exposed to distant tsunami generated by mega thrust earthquakes along the Sunda Subduction Zone, stretching south from Bangladesh and Myanmar to Southern Sumatra and Java; and the Makran Subduction Zone to the south of Iran and Pakistan [17]. Since Sri Lanka is far from all potential sources of earthquake-induced tsunami, there is sufficient time to issue early warnings and conduct evacuation. Tsunami arrival times from seismic events in different segments of the Sunda Subduction Zone – Andaman-Myanmar (Arakan), Northern Sumatra-Andaman, Southern Sumatra – and the Makran Subduction Zone, are in the ranges of 130–160, 95, 160–170, and 280 min, respectively [18]. The actual evacuation times at the disposal of each school depends on a complex set of 'upstream-downstream' interfaces from when Tsunami Service Providers (TSPs) detect a possible tsunamigenic earthquake, to when and how a school receives an early warning, such as from an early warning tower, telephone, or SMS [19].

The 2004 tsunami led to the creation of the Sri Lanka Disaster Management Act of 2005, which in turn established the National Council for Disaster Management and the DMC. The DMC is responsible for operating and coordinating tsunami early warnings and drills. Sri Lanka joined the Indian Ocean Member States who turned to UNESCO's Intergovernmental Oceanographic Commission (IOC) to set up a national tsunami early warning and mitigation system [20]. The early warning system partly comprises a network of tsunami early warning (EW) towers within populated areas along the coast of Sri Lanka.

The Intergovernmental Coordination Group (ICG) and Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) have subsequently conducted multiple "end-to-end" (from tsunami detection to evacuation) tsunami warning exercises [21]. In the last such drill in 2020, it took 40 + minutes for tsunami alerts to be issued and an additional 10 + minutes for evacuation orders to be issued to various coastal provinces (IOWAVE 20). The remaining 'downstream' time (between 45 and 240 min depending on tsunami source) makes tsunami preparedness and evacuation protocol essential to reducing life losses [22]. It is important here to highlight that owing to COVID-19 social-distancing measures in place at the time of the IOWAVE 20 tsunami drill and evacuation exercise, the public and the education system were not engaged in any capacity [21].

At school level, the MoE and National Institute of Education (NIE), in partnership with the Sri Lankan German Agency for Technical Cooperation (GTZ), created the "*National Guidelines for School Disaster Safety*". The guidelines outline seven steps in school safety planning. The first two steps include the establishment of *school safety nuclear teams* and creating awareness among the school community. The guidelines also outline the identification of hazards and resources, and the establishing and training of the school disaster safety team. Additionally, they require the preparation of the school safety plan, the dissemination of the plan, and, critically, the conduct of mock drills. Lastly, they advise the continuous evaluation and updating of the safety plan [23,24].

The UNDP's "*Regional Guide for schools to prepare for Tsunamis*" provides practical guidance to school administrators on preparing for and responding to tsunami. The document outlines how to execute tsunami drills and evacuations. This includes the development of a preparedness committee that can manage and coordinate risk reduction activities. All the above implies that the responsibility for tsunami preparedness and disaster management of schools lies primarily at the local school level, headed by their principals. The following study investigates the extent to which these policy and technical guidelines have been adopted and maintained within the education network since their inception. This study's strategy is to obtain most of this evidence from interviews with school principals, as they bear the primary responsibility for tsunami preparedness activities in Sri Lanka, supplemented by interviews with local and national officers with authority beyond the school.

3. Study method

This paper investigates the tsunami preparedness of Sri Lankan coastal schools through the findings of two sets of semi-structured interviews in the Ampara, Batticaloa and Galle districts: three of the most heavily affected districts in the 2004 tsunami. The first set of interviews is with eight regional and national education and disaster management officials. This includes three central officials, i.e., two from the NIE and one from the MoE, and five zonal officials. The second set of interviews is with 25 principals of coastal schools susceptible to tsunami inundation in the Ampara, Batticaloa and Galle districts. The surveys evaluate schools in terms of their fire and tsunami preparedness, including early warning and evacuation protocols, multi-hazard risk perceptions, risk awareness and disaster management capabilities. Taken together, the interviews provide insight to the extent to which official plans and measures are active at school level, as well as the coordination between schools and their respective disaster management services. The semi-structured interview tools, designed by the authors, are briefly described in the next section, and are presented in the supplementary material (ReSCOOL – Semi-structured Tsunami Preparedness Interview).

The semi-structured interviews were conducted between July and August 2020 on the authors' behalf by Vanguard Survey Ltd, a local survey agency with experience dating back to the 2004 tsunami. Vanguard Survey Ltd conducted the interviews face-to-face (in the interviewees' preferred language, Sinhala or Tamil) with appropriate Covid-19 safeguards; with follow up questions asked via telephone. Vanguard Survey Ltd also provided translations into English. The authors monitored the interviews through periodic checking. All the analysis presented in this study is by the authors.

3.1. Local and national government level interviews

The semi-structured interview tool adopted for education and disaster management officials structures questions around three themes, namely: 1) official guidance to schools on tsunami preparedness, 2) mechanisms in place to assess and control school preparedness, and 3) rehabilitation protocols following a tsunami event. The interviews conducted with these stakeholders aim to gather evidence on government policy and guidance towards tsunami risk, and to understand existing contingency measures and disaster management protocols. The interviews aim to evaluate the level of awareness interviewees have of relevant preparedness guidelines, policies, protocols, and responsibilities; and to evaluate the extent to which these are carried out at district and school levels. Finally, the interviews consider disaster management plans with the aim of understanding how rehabilitation and educational continuity might be managed following a tsunami event. This includes, for example, the management of losses to school functionality. The interviewed education and disaster management officials will henceforth be referred to as the 'officials'.

3.2. School level interviews

The interviews conducted with school principals aim to gauge whether schools have the necessary level of awareness, capacity, and practice, to ensure the safety of students and staff in a tsunami. The interviews look to identify the planning in place and the resources available to schools for minimizing disruption to the school's education functions post-disaster. Schools were selected based on their proximity to the coast and exposure to tsunami hazard, and on the basis that they were affected by the 2004 Indian Ocean tsunami [15]. They were also selected to represent the types of government schools in Sri Lanka - Type 1 A B – Grade 1–13, offering GCE Advanced Level Science, Arts and Commerce; Type 1C – Grade 1–13, offering GCE Advanced Level Arts and Commerce; Type 2 - Grade 1–11; Type 3 – Grade 1–5. The respondents of the school level interviews with school principals will be referred to as the 'principals' in the following text.

The semi-structured interview tool includes questions on multi-hazard risk perception and awareness; disaster management capacity, tsunami preparedness, and what happened to the school during the 2004 Indian Ocean tsunami. Elements around the emergency preparedness plan, early warning system and resource mobilisation capacity are adapted to the Sri Lankan context and objectives of this study from the UNDP questionnaire for *assessing student awareness and preparedness to tsunamis and earthquakes* [22]; Annex 3).

The questions are ordered to provide an indication of the school's baseline multi-hazard preparedness before explicitly discussing tsunami preparedness. The interviews use fire as a proxy for baseline preparedness as it is a high-frequency universal hazard. This is because the responses to both fire and tsunami emergencies require many of the same elements, such as effective alarm raising capabilities, sufficient practice in evacuations and drill simulations, and the identification of evacuation routes and refuges (although these are likely to differ between the two hazards). Some of the metrics the interviews use to capture the school's organizational and safety capacity are the number of staff and/or students trained and responsible for first aid, alarm raising, drills and evacuations. Furthermore, as disaster preparedness requires coordination with the wider community, such as the fire brigade and parent groups, a series of questions assess whether the necessary planning and lines of emergency communication are in place.

4. Findings and discussion

Overall, the responses of the 25 school principals together with the eight interviews with officials indicate that school baseline and tsunami preparedness is low. Principals perceive tsunami as the hazard they are *least* prepared for, followed by fire and by building degradation in the form of structural roof and column corrosion. Reports of severe building degradation were corroborated by engineering surveys presented in Cels et al., [15]. The interviews make clear that many of the risk reduction, management and preparedness responsibilities fall directly onto schools. Principals are responsible for the school's disaster management protocols, for conducting drills, and identifying the risks threatening the school. The principals have worked at their respective schools for an average of eight years (ranging from 0.5 to 24 years), either as principals or teachers, and four were at the school during the 2004 tsunami. As this paper will argue, it is not very evident that schools have the necessary resources to back up their responsibilities.

4.1. Responses from education officials

Table 1 summarises key sample questions and a select set of paraphrased responses obtained from the interviews with six officials. The interviews with the two NIE officials are excluded from Table 1 as their remit is restricted to developing the education syllabus. Several key observations from the interviews stand out. First, little consideration or guidance appears to be given to fire hazard in schools and the officials do not consider fire as posing a significant threat to schools (although the question did create some doubt with a few interviewees). The reason is that the officials were not aware of past fires in schools, except for one official who was aware of two instances of fire breakout in two schools (in the computer labs). During the past decade tsunami has dropped down the list of priorities of officials, and preparedness measures for it have received few funds. Table 1 makes clear that systematic tsunami guidance and training of pupils and teachers, the remit of the DMC, has significantly tapered off during this period. Although teachers are given first-aid training more systematically, tsunami specific training is not given. Moreover, schools do not

Table 1
Select responses from six education officials.

Sample Questions	Select responses	Count
What type of guidance is given to deal with fire?	• Fire is not considered a threat since there have been few or no cases of fire incidents. Consequently, no guidance is given.	6
What type of guidance is given to deal with tsunami?	• Guidance issued by DMC	3
	• No guidance or training given for numerous years (10 + years)	3
Who are the responsible officers in the schools for dealing with hazard (e.g., fire or tsunami) emergencies?	• Teachers and safety committees handle emergencies	6
Thinking about the curriculum, how do you expect children to learn about hazards and hazard preparedness, both in the community and the schools?	• Disasters are taught as part of the syllabus (Civic Education in grades 8 and 9) and during assemblies by principals.	5
Who is responsible for organising practice drills, how often are they carried out?	• Drills are coordinated and managed by the DMC who select schools for training (selection criteria and frequency of training unknown).	4
	• Schools do not conduct regular drills.	4
Is there a mechanism to ensure schools are implementing and following disaster protocols?	• There is no specific training program for tsunami disaster preparedness or management.	3
	• Schools have to submit disaster management plans, including the identification of evacuation routes within their Annual Implementation Plan (AIP).	4
	• Zonal teams sometimes check the implementation of disaster preparedness protocols during school visits but often focus on other priorities.	4
Is there a system for alerting schools to a tsunami threat?	• All principals are on a WhatsApp group together with the Zonal Coordinator.	5
	• Common expected source of warning is the media and news.	4

conduct regular tsunami training or drills. The DMC selects a number of coastal schools for tsunami drills and training each year, but the interviews indicate that these efforts are sporadic. Schools, through their safety committees, are expected to plan for and handle emergencies, including the development of their own emergency plans. There is no indication however, that schools receive the necessary support to draw up these plans. Lastly, all the zonal officials describe the existence of WhatsApp groups that include all the school principals in the district. The school principals use the WhatsApp groups to discuss common issues; they are sometimes used to communicate hazard warnings, such as storm or flood warnings. Once a member picks up the alarm from a media or news channel the officials expect this communication channel to disseminate potential tsunami warnings to individual school. This could perhaps be construed as an adaptation of a new technology, in the face of deficiencies and inadequacies in the older one (i.e., tsunami warning towers).

4.2. Perception of tsunami and other hazards

The school level interviews evaluate the perception school principals have towards tsunami and other hazards. This is so that the level of preparedness and risk perception to different hazards can be related to the frequency and experience of past hazard events. Fig. 2 indicates how many principals consider various hazards to be a risk to their school. All 25 principals indicate that tsunami is a potential threat to their school. There is a strong correlation between the perceived risk of a hazard and the school's experience of that hazard. Most principals that view a hazard as a risk to their school have experienced that hazard at least once in the past ten years (tsunami being an exception as the last tsunami occurred in 2004). Heavy storms and high winds feature as the second greatest perceived threat (11 principals). Fire is considered a risk by only one principal, whose school is the only one surveyed to have experienced a fire in the past decade. These perceptions go some length in explaining the very low levels of fire preparedness, as will be discussed later. Lightning is seen as a greater risk than fire, with four principals having had experience of lightning strikes (in their district). Earthquakes and landslides are not seen to constitute a risk by any of the principals. This is not surprising, as Sri Lanka is exposed to low levels of seismicity and none of the schools is in a mountainous region [25]. Roof and building degradation are hazards raised by seven principals, even though these risks did not feature in the survey. This included three schools from Galle, and two each from Batticaloa and Ampara. While roof and building degradation contribute to increased vulnerability against natural hazards, they also constitute a hazard, i.e., through collapse, even in the absence of significant external forces. Several principals who highlighted building degradation as a risk also expressed frustration at the lack of resources available to them for remedial repairs.

There is a noticeable split between the risk perception of school principals and that of the officials. Fig. 3 shows which hazards principals rank as posing the greatest risk to their schools. Acknowledging that there is a selection bias (in that the selection of schools is based on their tsunami exposure), principals unilaterally perceive tsunami as posing the greatest threat to the security of students and staff. By contrast, the hazard about which officials are mostly concerned is the management of Dengue fever outbreaks, which is "*the most common problems faced by schools every year*" (interview with Official No. 6). In the Ampara and Batticaloa regions, all but one principal selected tsunami as the hazard posing the greatest threat. This is reflective of the three districts' experience during the 2004 event [26]. By contrast, several officials admitted that the tsunami risk had fallen off the list of priorities, five years after the 2004 tsunami. Although schools were closed due to the COVID-19 central government fiat at the time of the interviews, COVID-19 outbreaks in these peripheral districts were still limited during this period. Mosquito-borne diseases, especially Dengue fever and

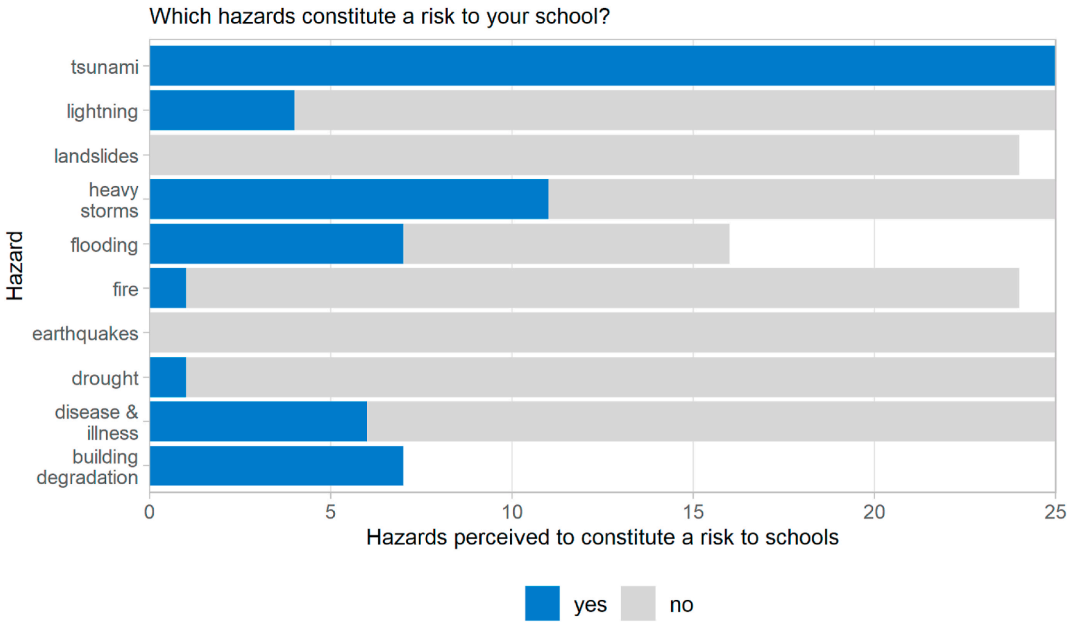

Fig. 2. Principals' responses on hazards perceived to constitute a risk to their school.

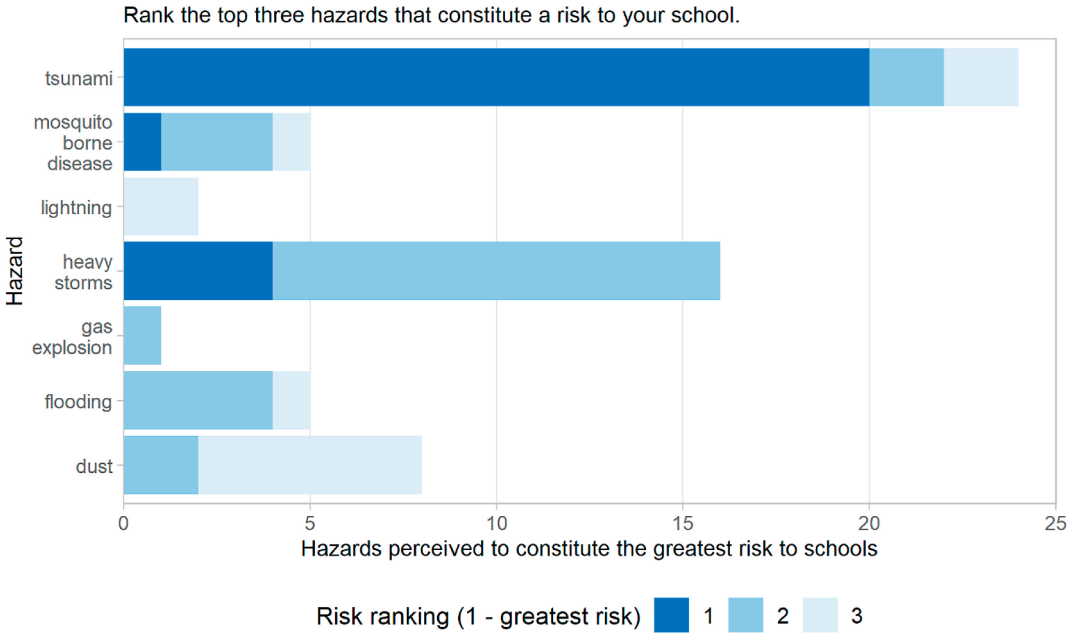

Fig. 3. Hazards perceived by principals to present the greatest risk to their schools in ranked order 1–3; 1 – greatest risk.

Lymphatic Filariasis are endemic in Sri Lanka, with high caseloads coinciding with monsoon rains during June-July and October–December [25,27].

There is also a clear disconnect between the risk perception of schools and what schools communicate back to officials. This is illustrated by the response of one zonal official – *"In fact, most of the coastal schools have not identified [tsunami] as a threat or possible disaster"*. This raises the question of why the perceived tsunami risk has not featured as a prominent issue in the past decade between school principals and zonal officials. One factor may be that, as with the officials, the principals are reacting to other more immediate concerns, as suggested by one zonal official: *"We have various issues such as a lack of proper classrooms, shortage of buildings, shortage of desks and chairs; hence, this [tsunami preparedness] kind of requirement takes the last position in the priority list, so we hardly worry."*

Amongst the principals there is a strong correlation between experience and perceived risks. Lightning and gas explosions are the only two hazards which principals have observed that have not directly affected their schools in the past. Principals consider heavy storms, (which have caused roof tiles to be displaced in several instances), and floods to be the hazards that are most likely to cause

the greatest disruption to teaching activities (9 and 4 principals, respectively). Both these hazards have high frequency and impact rates. Five schools indicate that flooding, typically associated with the monsoon seasons, have led to school closures in the last 10 years, evaluating these as being between 10 and 40 school closures over this period. Four out of the five affected schools ranked flooding as the second and third greatest risk. Flood-induced access issues are seen as the hazard mostly likely to cause a drop in student attendance (6 principals). Tsunami and building/roof degradation are seen as the next likely causes (3 principals each). Eighteen principals did not respond to the question as to which hazard would result in a drop in attendance.

4.3. School disaster management capacity

Most of the interviewed schools (80%) have safety committees modelled after the *National Guidelines for School Disaster Safety* guidelines. The schools set up safety committees to include the school principal, teachers, students and in some cases parents. Not all committee members have adequate training in first-aid, alarm raising, evacuation simulation, and security. Most principals describe sporadic teacher training, with intervals between trainings usually spanning several years, except for first aid training which is mostly given annually or "on occasion". Many of the initial efforts to train teachers in risk reduction and disaster management activities following the 2004 tsunami are reported to have waned. Furthermore, several schools report a gradual knowledge and experience drain, i.e., that the teachers with training have long since left the school.

Figs. 4 and 5 show the number of students per staff member responsible for alarm raising and trained in evacuation, respectively. In the Ampara, Batticaloa and Galle regions the average is 622, 134 and 683 students per member of staff trained in alarm raising, respectively. The duty of alarm raising falls on the principal or a designated teacher in all the surveyed schools. Some 70% of the schools also assign this responsibility to parents and a further three (12%) to school alumni in the community. Despite these efforts, 20 out of 25 schools have not participated in any tsunami alarm training drills. One reason is that there is no enforcement mechanism in place at zonal or national level to compel schools to conduct training drills. More fundamentally however, other hazards and issues are given greater priority. According to one official, momentum for tsunami resilience and preparedness activities has simply died down – "*Advice was given to the schools about [tsunami] safety measures, but it slowly died down after about 4 to 5 years [following the 2004 tsunami]. I must admit that all the measures are time bound and after a while these are forgotten*".

Only 12 out of the 25 schools have evacuation simulation teams within their safety committees, all of whom selected tsunami as the hazard posing the greatest risk to their school. Out of these, only 7 schools (four in Ampara, one in Batticaloa and two in Galle) report that their teachers have participated in disaster response training, with two schools participating in training on an annual basis and three on a biennial basis. Of Figs. 4–6, only Fig. 5 has schools without any teachers allocated to the relevant preparedness measure – i.e., evacuation simulation (13 out of 25 schools with '0' indicated). The *National Guidelines for School Disaster Safety* stipulates that all teachers and prefects should be able to direct and evacuate pupils along evacuation routes to the safe assembly points. In other words, all teaching staff should be trained and able to evacuate their classrooms to the evacuation point.

All principals report having at least one teacher with first-aid training (Fig. 6). Eleven of the principals report annual first-aid training and 10 report either providing first aid training on occasion or at bi-annual intervals. Zonal Divisions organise most first aid training, but two principals report additional first aid training in conjunction with St. John's ambulance service.

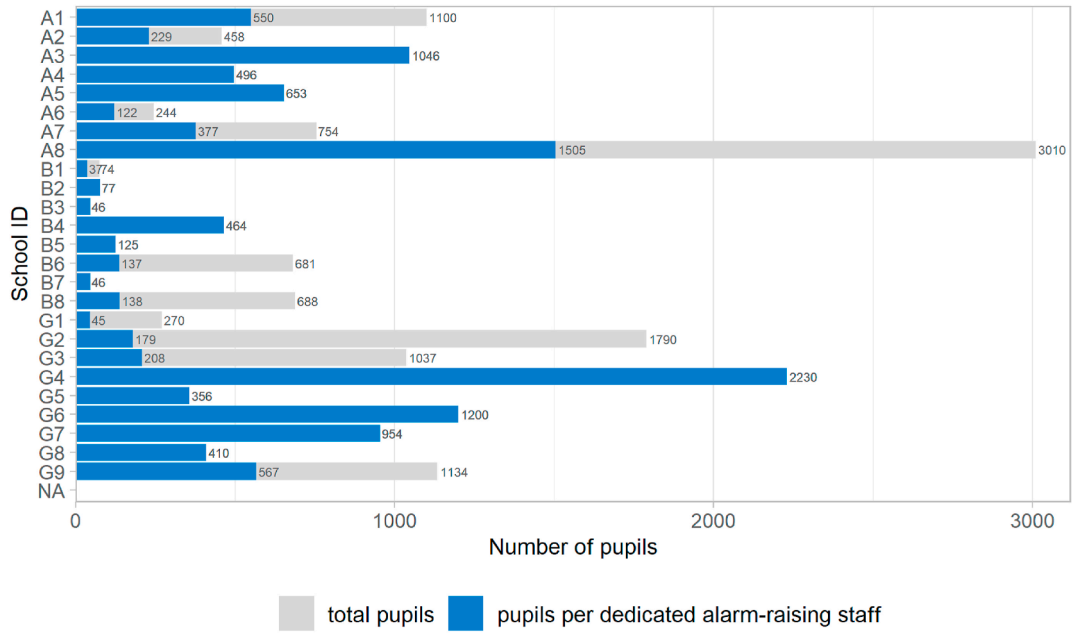

Fig. 4. Number of pupils in total, and number of pupils per staff member responsible for alarm raising (codes on the Y-axis refer to the interviewed schools; A, B and G are codes for Ampara, Batticaloa and Galle, respectively).

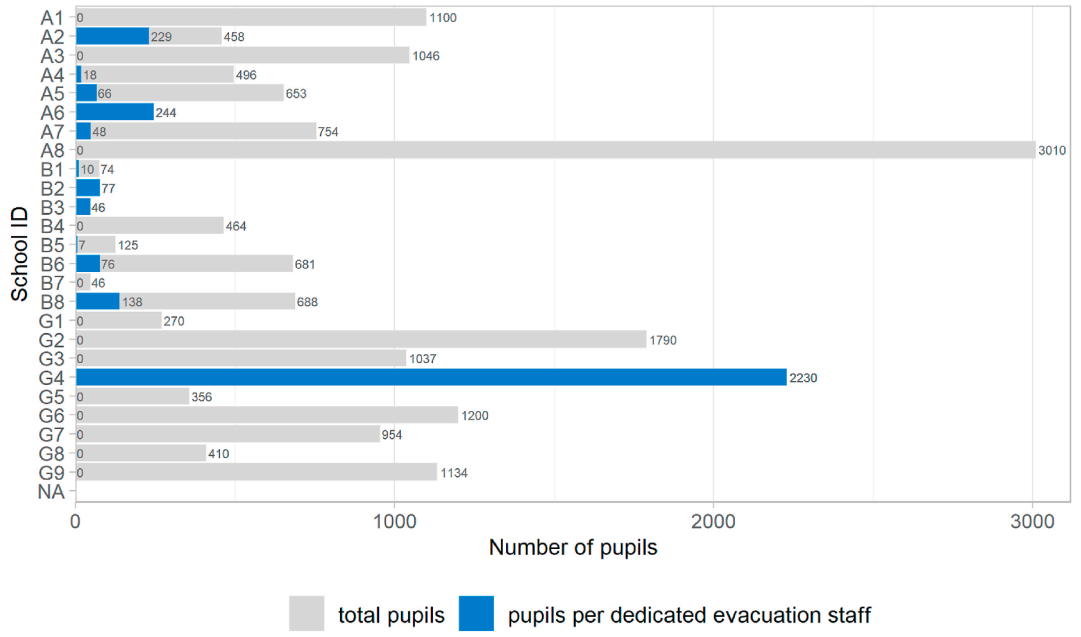

Fig. 5. Number of pupils in total, and number of pupils per staff member involved in evacuation simulation (codes on the Y-axis refer to the interviewed schools; A, B and G are codes for Ampara, Batticaloa and Galle, respectively).

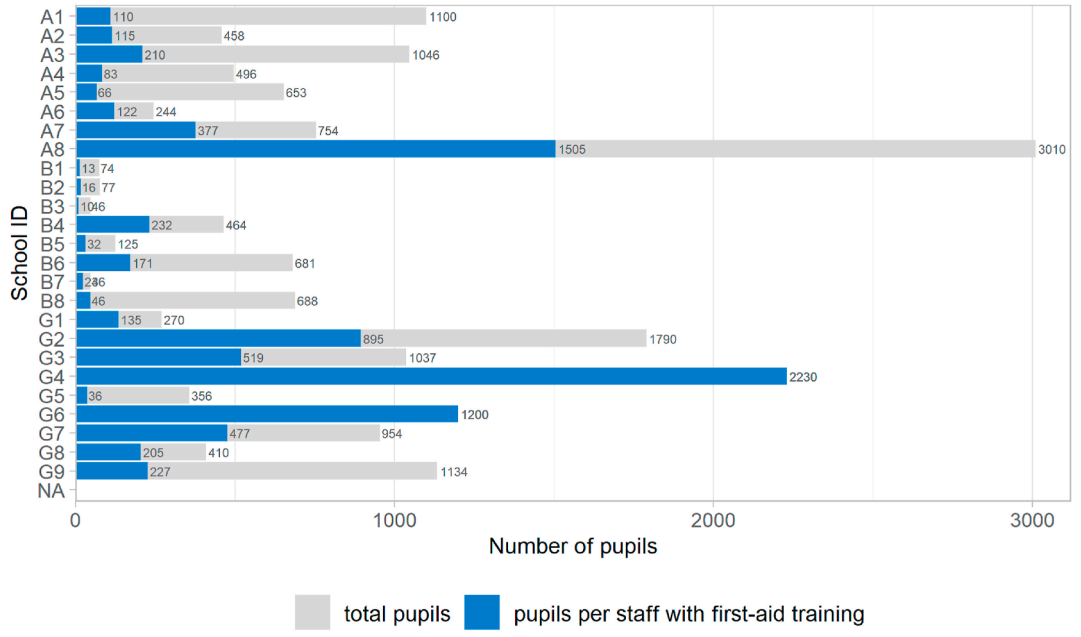

Fig. 6. Number of pupils in total, and number of pupils per staff member with first-aid training (codes on the Y-axis refer to the interviewed schools; A, B and G are codes for Ampara, Batticaloa and Galle, respectively).

A key mechanism for monitoring the implementation of preparedness measures is the Annual Implementation Plan (AIP), wherein each school is required to develop a disaster management plan. The Provincial Education Ministries approve AIPs, which form part of school budget proposals. The Education Ministries require schools to identify key threats and plan mitigating actions. Despite tsunami being the principals' greatest perceived threat to schools, zonal officials report that most coastal schools have not included tsunami mitigation measures within their AIPs for several years. Zonal officials also describe a large discrepancy in the level of detail included in the emergency management plans submitted by different schools. Probable causes include the absence of feedback loops between schools and officials, the lack of clear information and training; the absence of a set of standards and/or difficulties in enforcing them.

As reported by the district and national level officials, the education authorities' guidance and support has focused mostly on managing dengue fever, health, and, following the Easter bombings in April 2019, security. This is evident in the number of staff with se-

curity training as part of the safety committees shown in Fig. 7. In terms of dedicated training, the surveyed schools (overall) have the highest number of staff dedicated to school security (167 staff), followed by first-aid (111 staff), evacuation (100 staff) and alarm raising (58 staff). Although the Easter bombings briefly focused minds and spurred new efforts to improve school security, the event has not led to concerted efforts to hold regular evacuation drills. Only ten schools have participated in tsunami drills at any point, eight of which are in the Galle district.

Table 2 shows the Pearson's correlation coefficients among the various preparedness measures in all the schools using the number of students per staff trained for such measures - i.e., correlations among the data distributions in Figs. 4–7. There is a strong correlation between the first-aid measures and the alarm raising measures, and also between them and the evacuation measures. This supports remarks by two officials that evacuation training is included – although limited in scope – as part of first-aid training, which is the most frequent and systematic form of disaster/emergency related teacher training. It also reveals that there is consistency across schools in the relative resources they commit (trained teachers per students) towards the above preparedness measures, although such commitments vary widely from one school to another. The comparatively low level of correlation between the security measures and the others indicates that the relative requirements or priorities for security preparedness across the schools vary widely from those for the other preparedness measures. This observation supports the assertion by interviewed officials that efforts to improve school security have not had a significant impact on the other preparedness measures or on overall school preparedness. Note that while the correlation between the first aid training and alarm raising measures are based on the full dataset from 25 schools, the others rely only on somewhat reduced sets, either because no teachers were allocated to those measures or because principals had not supplied the information.

4.4. Tsunami risk awareness and education

Fig. 8 depicts the main sources from which principals obtain tsunami risk and awareness information. It shows that principals obtain much of their information from the Civil Services. It also indicates sources that could act as effective channels, especially

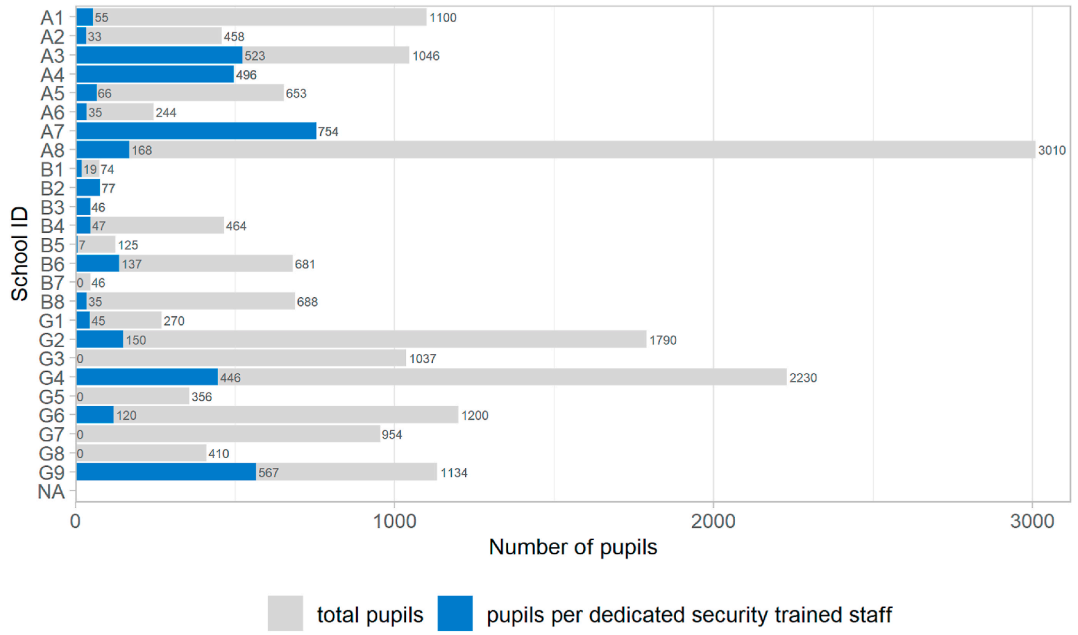

Fig. 7. Number of pupils in total, and number of pupils per staff member with security training (codes on the Y-axis refer to the interviewed schools; A, B and G are codes for Ampara, Batticaloa and Galle, respectively).

Table 2
Pearson's correlation coefficients (r) among the various preparedness measures.

	Number of students per staff with first-aid training	Number of students per staff for alarm raising	Number of students per staff with evacuation training	Number of students per staff with security training
Number of students per staff with first-aid training	1	0.84 ($p < 0.01$)	0.98 ($p < 0.01$)	0.25 ($p > 0.10$)
Number of students per staff for alarm raising		1	0.94 ($p < 0.01$)	0.40 ($p > 0.05$)
Number of students per staff with evacuation training			1	0.30 ($p > 0.10$)
Number of students per staff with security training				1

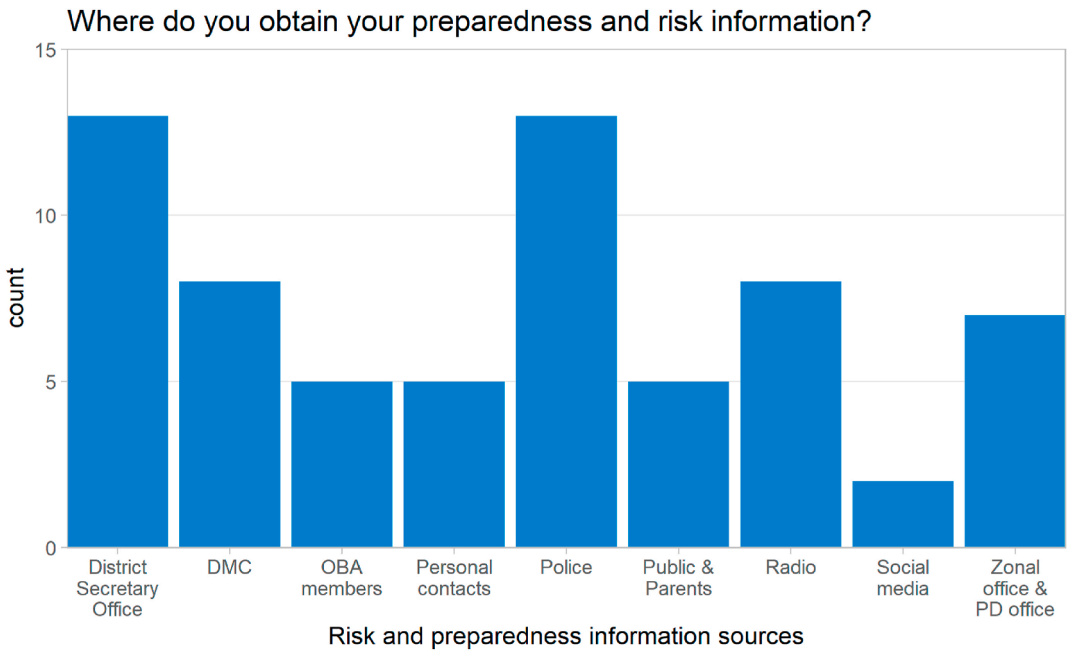

Fig. 8. Tsunami risk and response awareness sources (OBA: Old Boys Association).

parent groups, to disseminate early warnings and preparedness information. Parent groups could increase the likelihood and speed that the early warnings reach the school. Whereas the police and emergency services would need to work their way down an emergency list of schools, hospitals, and other critical institutions, parents are likely to try and communicate with the school or their child immediately after receiving an early warning.

The syllabus does not include specific information on how to evacuate or prepare for tsunami (at home or at school). The authors note that the NIE has no authority to write and issue evacuation procedures for schools, this being within the purview of the Ministry of Education, and Provincial and Zonal Directors of Education. Only four of the principals interviewed felt that the school curriculum addresses tsunami preparedness. Five principals report the availability of swimming lessons as part of the physical exercise syllabus as an extra-curricular activity: this is seen as a useful skill in the case of tsunami inundation or flooding events. There is a recognition amongst the MoE and zonal officials that the curriculum does not *"adequately cover tsunami or another major disaster" and that "very little is taught about these disasters"*.

4.5. The 2004 Indian Ocean tsunami's impact on the 25 surveyed schools

The 2004 tsunami claimed the lives of approximately 320 students and six teachers across the 25 interviewed schools. Six schools suffered the complete collapse of school buildings and thirteen report severe damage to school buildings. Since 2004, only one of the schools was relocated to a new and less exposed location. Strikingly, 52% of schools earmarked for relocation in Sri Lanka moved to locations within the DMC tsunami hazard zone [10,11]. Those not relocated were mostly reconstructed in the same location or were amalgamated with other schools. In Ampara at least 10 out of 18 relocated schools are within the tsunami inundation zone, and the figures in Batticaloa are 10 out of 13 and in Galle, 8 out of 14. This highlights some of the difficulties that education officials and disaster managers face during recovery and reconstruction.

The main objective of the MoE in the immediate aftermath of the tsunami was to return affected children to the classroom as quickly as possible. Two of the 25 schools surveyed served as IDP camps. Five schools conducted lessons in temporary shelters (for approximately 6 months) and seven returned to normal operations after modest building repairs. Most schools returned to normal functionality within two years of the event if they sustained heavy damage and had to relocate and/or rebuild. Less affected schools were repaired and mostly returned to full functionality within a period of 2–3 months.

Several factors significantly impacted students' attendance in the months and years following the tsunami. Although school enrolment recovered within a year in most affected regions [9], principals reported a significant drop in student participation. Principals highlighted the stresses imposed on students and staff having to live in IDP camps and deal with shortages in essential items such as clothes and teaching material. This stress is in addition to the psychological trauma the event inflicted. NGOs provided counselling services for approximately 2 years but with limited outreach [9].

4.6. Baseline fire and tsunami preparedness

Overall, schools have a low baseline level of fire preparedness. The lack of fire preparedness stems from the absence of regular fire drills and basic fire protection in all the schools. Only 2 out of 25 schools conduct fire drills, one of which reported a fire incident. This school was also the only school that considered fire to constitute a risk to the school (see Fig. 2). Only two schools have fire alarm sys-

tems in place. None of the schools have fire suppression equipment of any kind (e.g., fire blankets, sprinklers, extinguishers). In terms of drills and evacuation practice, it appears that, surprisingly, schools are moderately more prepared for tsunami than fire, although the number of drills is low for both.

Ten schools participated in a tsunami drill in the past ten years, although only 3 conduct regular drills on an annual or biannual basis. This highlights a major obstacle in risk preparedness, namely that staff and students are not practised in drill simulations and in responding to alarms. Most officials recognize that schools do not systematically carry out any kind of drill, for example: *"Schools do not conduct any drills regularly. We need to ask them to do it regularly"*. Organising drills falls under the purview of the DMC; however according to one official, the last time the DMC conducted drills in the Batticaloa district and provided teacher/student training was in 2015.

Sixty percent of schools state that they have planned evacuation routes (plans which form part of the AIP requirements). It is the principal and/or teachers' groups that draw up the evacuation plans. Temples, which are often inland, serve as the designated evacuation zone for four schools. Six schools have plans to evacuate children to the upper floors of school buildings. As previously highlighted, Sri Lankan schools do not have tsunami structural design provisions. Schools are thus questionable refuges for evacuation, and this is especially so the lower the structure [38]. Five schools indicate they have an emergency tsunami response plan drawn up by the school and community, and in two of these cases with additional input from government institutes. Only one school has a post tsunami management plan (though the school did not provide any details during the interview).

4.6.1. Early warning

Past tsunami early warning exercises indicate that schools should have enough time to evacuate; the appropriateness of vertical versus horizontal evacuation will vary between schools and is beyond the scope of this paper. The interviews with principals reveal a strong reliance on tsunami early warning (EW) for evacuation, particularly from tsunami EW towers. This finding is in line with that of Rathnayake et al. [28] who found that the EW towers were the preferred mode of receiving tsunami early warnings by coastal communities in Sri Lanka. However, this is somewhat at variance with the education officials, who seemed to view WhatsApp groups as vehicles for EW. According to administrative official interviews and based on past tsunami drills, the EW towers have a maximum audible radius of 1 km [28]. Fig. 9 depicts the locations of schools within the DMC tsunami inundation zone and the tsunami EW towers with the 1-km audible range, as drawn by the authors using data from the DMC data portal [29]. There are currently 430 coastal schools in Sri Lanka that lie within the footprint of the DMC tsunami inundation zone, amounting to over 193,000 pupils according to the 2019 school census [11,16]. Of the schools exposed to tsunami, only 215 are within direct earshot of an EW tower, leaving the remainder dependent on secondary sources of warning. Tsunami early warning dissemination therefore needs greater redundancy and outreach. This point was clearly illustrated by a false tsunami warning in 2012, in which 10 of the 74 EW towers built at the time did not work [30]. Of the schools interviewed as part of this study, only two confirmed they had received a warning in the 2012 alarm, with the rest either stating they did not receive the warning (3 schools) or did not know (10 schools).

Anecdotal evidence from one of the principals highlights the need to integrally involve parents and community groups in evacuation planning. At the sound of the tsunami warning during a false warning in 2019, many parents rushed into the school premises to extract their children. This contributed to panic and chaos and undermined the schools' evacuation efforts. Ideally, parents should be aware of the evacuation routes and where to safely reunite with their children. Undoubtedly this requires a lot of trust in the schools' ability to evacuate its students, again highlighting the importance of regular practice drills.

5. Concluding discussion

Schools facilitated community recovery and educational continuity in the aftermath of the 2004 Indian Ocean tsunami. The disaster demonstrated that the best way of assuring the resilience of a child's education, without knowing the precise nature, timing, or magnitude of the next disaster, is to understand the classroom within a wider system. Comprehensive school preparedness can ensure that risks are mitigated throughout the education network, ensuring that the failure of a single component does not lead to the collapse of the entire system. The 2004 Indian Ocean tsunami highlighted that a dependence on the physical security of building assets neither fully protects against catastrophic human losses, nor enables a coordinated and resilient response. There are currently 430 schools directly exposed to tsunami in Sri Lanka, most of which were built to the same pre-tsunami designs, without any tsunami strengthening measures [15]. Tsunami preparedness, including effective evacuation and system-wide disaster management strategies, are therefore essential. Disaster risk reduction efforts in Sri Lanka should thus focus on ensuring system-wide educational service continuity rather than solely relying on the strength and safety of physical assets. This point has been clearly emphasised by the recent COVID-19 emergency when physical school attendance was severely impeded. Through the use of 25 semi-structured interviews with school principals in the Ampara, Batticaloa and Galle districts, together with 8 interviews with education, government and disaster management officials, the present study evaluated the tsunami preparedness of the school system in Sri Lanka.

It is found that in Sri Lanka, school principals hold much of the responsibility for preparing their schools against tsunami-related threats. These principals are aware of the tsunami hazard facing their schools and acknowledge that tsunami is the hazard their schools are least prepared for. This is positive, as risk awareness is a necessary first step to engaging with or adopting risk reduction measures [31]. However, simply being aware of a risk is not enough to ensure the adoption of risk reduction measures. Limits in capacity, budget, time, agency and other contending demands are all likely to hamper the adoption of risk reduction measures [31–34]. This is especially so for a hazard such as a tsunami with very long and variable return periods, which, in the case of Sri Lanka, ranges between hundreds to thousands of years [35]. Placing disaster risk reduction responsibilities directly onto schools can lead to greater empowerment and the development of more contextualised solutions. However, the interviews conducted for this research indicate

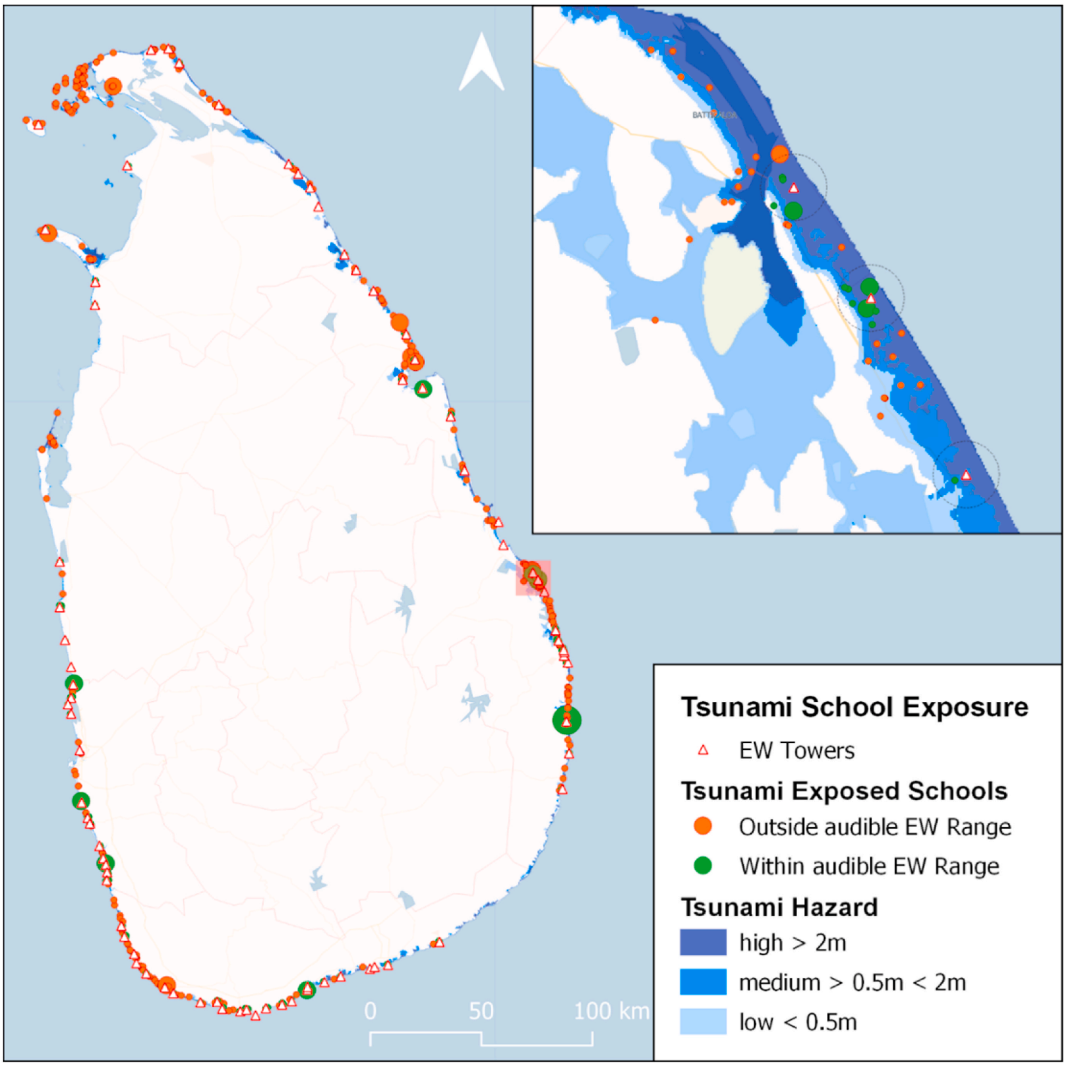

Fig. 9. Coastal schools within tsunami early warning tower range; enlarged window of the Batticaloa district. Data from the Coastal Research and Design Division of the Coast Conservation and Coastal Resource Management Department; and Disaster Management Centre Sri Lanka (2012); and Ministry of Education (2019).

that not all schools are receiving the support and resources required to, for example, draw-up evacuation plans and identify evacuation refuges. Principals are given responsibility for the school's evacuation protocol without being provided a clear understanding of the hazard and risk. For example, some principals designate the upper floor of their 2-3 storey school building as the safety refuge, despite the same structure not being structurally designed to resists tsunami loads [38], and being within the 2004 tsunami inundation zone [11]. Also, many schools do not appear to have a dedicated teacher for evacuation simulation. The authors therefore recommend that the Ministry of Education, together with the Provincial and Zonal Departments provide guidance and work with schools to develop their evacuation plans and procedures.

Only 10 of the 25 schools interviewed have participated in a tsunami drill in the past ten years. The number of schools that conduct regular drills on an annual or biannual basis reduces to only 3 schools. Despite Sri Lanka's "*National Guidelines for School Disaster Safety*" requiring that all teachers are able to guide their classes to evacuation refuges along predefined evacuation routes, schools and teachers are unprepared. Teachers have a limited awareness and insufficient training and resources to carry out emergency evacuation functions. Teachers however need to be able to act on planned evacuation routes and designated evacuation refuges/points, something which many schools lack. Additionally, evacuation protocols need to account for pupils and staff with special needs to reach the tsunami evacuation point, which they currently do not. Teachers do however receive regular training on curriculum developments and teaching methods. This provides an opportunity to integrate tsunami preparedness and evacuation training within the curriculum. The authors therefore recommend that the NIE and MoE (with others) integrate hazard preparedness education with other areas of the curriculum and encourage the regular adoption of hazard safety/drill practice to reinforce learning.

Parent involvement and awareness of the evacuation plan is critical to ensure successful evacuation and parent-child reunification. Many schools in New Zealand practice regular 'family reunification' drills, whereby parent groups participate in evacuation

drills by meeting their child at the evacuation refuge/point. When parents are unaware of the school's evacuation plan, their first instinct is likely to be to try and reach the school rather than evacuate themselves, as happened in the 2019 false tsunami warning in Sri Lanka. This can aggravate the crisis and impair the school's ability to respond, for example by contributing to traffic and chaos, as well as putting themselves under greater risk [36,37]. New Zealand protocol also recommends that schools should prepare 'get-away' kits to take during evacuation, which include first aid kits, lists of students and parent contact details, a portable radio and student medicines [37]. The authors would add to this list a satellite telephone, in the likely case that there is extended disruption to the telecommunication network. Another suggestion is to incorporate tsunami preparedness and evacuation into the school curriculum, which can also serve to encourage tsunami preparedness at home. However, regular community-wide "end-to-end" practice drills, such as in future Indian Ocean Wave exercises (IOWAVE), involving schools, parents and emergency services, is the best way of improving the tsunami preparedness of the education system in Sri Lanka.

Apart from being ready to act on a tsunami early warning and implement effective evacuation procedures, there is a deficiency in early warning transmission to schools. The 25 school principals interviewed in this study indicate a heavy reliance on early warning towers to provide an early warning. As this paper presents, half of the 430 schools within the national tsunami hazard zone are outside the direct audible range of a tsunami early warning tower. To ensure schools have sufficient time to carry out evacuations, early warning communication channels and backup systems need to be in place (several warning towers failed to operate in a false early warning in 2012). The integration of mobile phones into early warning procedures should also be studied and streamlined.

Tsunami preparedness should also extend to post disaster planning and preparation. In terms of educational continuity, Sri Lanka managed to bring most children back into a learning environment within two months of the 2004 tsunami. This was accomplished primarily by pooling resources from the wider education network, for example by transferring students to undamaged schools further inland. Planning in advance of a disaster how coastal schools might gain support from the wider school network could help to reduce extended educational disruptions in future tsunami events. For example, schools could pair with other schools outside the tsunami hazard zone, to which pupils and teachers would be transferred in case of a disaster. In addition, school premises outside the inundation zone could feasibly serve as evacuation points (large open sport fields) for those directly in the inundation zone.

The work presented in this paper forms part of the UK Global Challenges Research Fund project ReSCOOL (Resilience of Schools to Extreme Coastal FlOOding Loads), which will develop a number of tsunami school damage scenarios. These scenarios together with the findings of this paper have the aim of providing a focus for school and education stakeholder tsunami preparedness planning in Sri Lanka.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Tiziana Rossetto reports financial support was provided by UK Global Challenge Research Fund. Tiziana Rossetto reports a relationship with Vanguard Ltd that includes: non-financial support.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2022.103473.

References

[1] D. D'Ayala, C. Galasso, A. Nassirpour, R.K. Adhikari, L. Yamin, R. Fernandez, D. Lo, L. Garciano, A. Oreta, Resilient communities through safer schools, Int. J. Disaster Risk Reduc. 45 (2020) 101446, https://doi.org/10.1016/j.ijdrr.2019.101446.

[2] UNISDR, & GADRRRES, Comprehensive school safety: a global framework in support of the global alliance for disaster risk reduction and resilience in the education sector and the Worldwide initiative for safe schools, Global Alliance for Disaster Risk Reduction & Resilience in the Education Sector, 2017 In www.undrr.org (March, p.8). https://www.undrr.org/publication/comprehensive-school-safety.

[3] UNISDR, Sendai Framework for Disaster Risk Reduction 2015-2030 (Issue 1) (2015).

[4] R. Paci-Green, A. Varchetta, K. McFarlane, P. Iyer, M. Goyeneche, Comprehensive school safety policy: A global baseline survey, Int. J. Disaster Risk Reduc. 44 (2020), 101399 https://doi.org/10.1016/j.ijdrr.2019.101399, October 2019.

[5] H. Aturupane, A.W. Little, General education in Sri Lanka, in: P. Sarangapani, R. Pappu (Eds.), Handbook of Education Systems in South Asia, Global Education Systems. Springer, Singapore, 2020. https://doi.org/10.1007/978-981-13-3309-5_18-1.

[6] H. Dundar, B. Millot, M. Riboud, M. Shojo, H. Aturupane, S. Goyal, D. Raju, World Bank Group, Sri Lanka education sector assessment: achievements,

challenges, and policy options, https://doi.org/10.1596/978-1-4648-1052-7, 2017.
[7] S. Jayasuriya, P. Steele, D. Weerakoon, The Institute of Policy Studies (IPS) of Sri Lanka, Asian Development Bank Institute (ADBI), The Asian Economics Centre, University of Melbourne, Post-tsunami recovery: issues and challenges in Sri Lanka, Asian Development Bank Institute (ADBI) Research Paper Series No. 71, 2006. http://www.adbi.org/files/2006.06.rp71.tsunami.recovery.english.pdf.
[8] S. Wickramaratne, J. Ruwanpura, S.C. Wirasinghe, Analysis of plans for tsunami related evacuations in Sri Lanka, in: Proceedings of the 3rd WFEO-JFES-JSCE Joint International Symposium on Disaster Risk Management, Fukuoka, Japan, 2009.
[9] UNICEF Evaluation Office, Children and the 2004 Indian Ocean Tsunami: evaluation of UNICEF's response in Sri Lanka, Country Synthesis Report (Issue November) (2009).
[10] The Education Rehabilitation Monitor, Reconstruction and rehabilitation program of tsunami affected schools, in: TERM, October 2009.
[11] DMC, Tsunami Hazard Map, Disaster Management Centre, Colombo, 2012.
[12] J. Wijethunga, S. Piyasiri, Hazard profiles of Sri Lanka: Tsunami, http://www.dmc.gov.lk/hazard/hazard/Report.html, 2012.
[13] T. De Mel, M. Sivagnanam, *Sri Lanka's education sector following the 2004 Indian Ocean tsunami*, Interview, 2022.
[14] Coast Conservation Department, Setback standards for development activities in the coastal zone by segment, https://www.coastal.gov.lk/images/pdf/Coastal_Setback.pdf, 2021.
[15] J. Cels, T. Rossetto, P. Dias, J. Thamboo, K. Wijesundara, M. Baiguera, M. Del Zoppo, Engineering surveys of Sri Lankan schools exposed to tsunami, Pending Acceptance - Frontiers in Earth Science - Geohazards and Georisks, 2022, pp. 1–27.
[16] Ministry of Education, Annual school census of Sri Lanka, http://www.statistics.gov.lk/Education/StaticalInformation/SchoolCensus/2019, 2019.
[17] J. Wijetunge, Assessment of potential tsunamigenic seismic hazard to Sri Lanka, International Journal of Disaster Resilience in the Built Environment 1 (2) (2010) 207–220, https://doi.org/10.1108/17595901011056659.
[18] J. Wijetunge, Nearshore tsunami amplitudes off Sri Lanka due to probable worst-case seismic scenarios in the Indian Ocean, Coast. Eng. 64 (2012) 47–56, https://doi.org/10.1016/j.coastaleng.2012.02.005.
[19] R. Haigh, M.M. Sakalasuriya, D. Amaratunga, S. Basnayake, S. Hettige, S. Premalal, A. Jayasinghe Arachchi, The upstream-downstream interface of Sri Lanka's tsunami early warning system, International Journal of Disaster Resilience in the Built Environment 11 (2) (2020) 219–240, https://doi.org/10.1108/IJDRBE-07-2019-0051.
[20] IOC-UNESCO, Preparing for community tsunami evacuations: from inundation to evacuation maps, response plans and exercises (2020) 298 pp.
[21] Dilanthi Amaratunga, R.P. Haigh, Sarath Premalal, Chandana Siriwardana, Observer report on exercise Indian Ocean Wave 2020, https://doi.org/10.13140/RG.2.2.12844.39041, 2020.
[22] UNDP, Regional guide for schools to prepare for tsunamis, https://reliefweb.int/sites/reliefweb.int/files/resources/RBAP-RSD-2019-Regional-Guide-for-Schools-to-Prepare-for-Tsunamis.pdf, 2019.
[23] M. Donga, P. Bitter, Sri Lanka: teaching disaster risk management in Sri Lanka's schools: experience since the 2004 tsunami, 2008.
[24] Ministry of Education and National Institute of Education, National Guidelines for School Disaster Safety (2008).
[25] T. Rossetto, J. Twigg, P. Dias, S. Shanaka, M. Baiguera, D. Robinson, Sri Lanka Building Regulatory Capacity Assessment (BRCA), Building Regulation for Resilience Program (No 1258029), The World Bank, 2019.
[26] UNHCR, Deaths Caused by Tsunami by District, The UN Refugee Agency, 2004.
[27] WHO, Dengue fever – Sri Lanka, https://www.who.int/emergencies/disease-outbreak-news/item/19-july-2017-dengue-sri-lanka-en, 2017.
[28] D.K. Rathnayake, D. Kularatne, S. Abeysinghe, I. Shehara, T. Fonseka, S.D.J. Edirisinghe Mudiyanselage, W.G.C.T. Kamalrathne, C. Siriwardana, C.S.B. Alagiyawanna Mohotti Appuhamilage, R. Dissanayake, Barriers and enablers of coastal disaster resilience – lessons learned from tsunami in Sri Lanka, International Journal of Disaster Resilience in the Built Environment 11 (2) (2020) 275–288, https://doi.org/10.1108/IJDRBE-07-2019-0050.
[29] Disaster Management Centre of Sri Lanka, RISKINFO (2022). https://riskiadnfo.lk/layers/?limit=10&offset=0.
[30] S. Wickramaratne, J. Ruwanpura, S.C. Wirasinghe, A Review of preparedness planning for tsunamis in Sri Lanka, in: 9th Annual International Conference of the International Institute for Infrastructure Renewal and Reconstruction (IIIRR), 2013.
[31] H. Joffe, T. Rossetto, C. Solberg, C. O'Connor, Social representations of earthquakes: a study of people living in three highly seismic areas, Earthq. Spectra 29 (2) (2013) 367–397, https://doi.org/10.1193/1.4000138.
[32] J.S. Becker, D. Paton, D.M. Johnston, K.R. Ronan, A model of household preparedness for earthquakes: how individuals make meaning of earthquake information and how this influences preparedness, Nat. Hazards 64 (1) (2012) 107–137, https://doi.org/10.1007/s11069-012-0238-x.
[33] H. Joffe, G. Perez-Fuentes, Henry, W.W. Potts, Tiziana Rossetto, How to increase earthquake and home fire preparedness: the fix-it intervention, Nat. Hazards 84 (2016) 1943–1965, https://doi.org/10.1007/s11069-016-2528-1.
[34] C. Solberg, T. Rossetto, H. Joffe, The social psychology of seismic hazard adjustment: re-evaluating the international literature, Nat. Hazards Earth Syst. Sci. 10 (8) (2010) 1663–1677, https://doi.org/10.5194/nhess-10-1663-2010.
[35] K.L. Jackson, G.P. Eberli, F. Amelung, M.A. McFadden, A.L. Moore, E.C. Rankey, H.A.H. Jayasena, Holocene Indian Ocean tsunami history in Sri Lanka, Geology 42 (10) (2014) 859–862, https://doi.org/10.1130/G35796.1.
[36] V.A. Johnson, D.M. Johnston, K.R. Ronan, R. Peace, Evaluating children's learning of adaptive response capacities from shakeout, an earthquake and tsunami drill in two Washington state school districts, J. Homel. Secur. Emerg. Manag. 11 (3) (2014) 347–373, https://doi.org/10.1515/JHSEM-2014-0012/PDF.
[37] D. Johnston, R. Tarrant, K. Tipler, E. Lambie, M. Crawford, V. Johnson, J. Becker, K.R. Ronan, Towards tsunami-safer schools in the Wellington region of New Zealand: Evaluating drills and awareness programs, Aust. J. Emerg. Manag. 31 (3) (2016) 59–66, https://doi.org/10.7717/peerj-cs.386/table-1.
[38] M. del Zoppo, K. Wijesundara, T. Rossetto, P. Dias, M. Baiguera, M. di Ludovico, J. Thamboo, A. Prota, Influence of exterior infill walls on the performance of RC frames under tsunami loads: case study of school buildings in Sri Lanka, Eng. Struct. 234 (2021), https://doi.org/10.1016/j.engstruct.2021.111920.