Barriers and enablers of coastal disaster resilience – lessons learned from tsunami in Sri Lanka

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Received 31 July 2019
Revised 11 October 2019
28 November 2019
Accepted 28 November 2019

Abstract

Purpose – This study aims to evaluate the coastal disaster resilience and the disaster management framework of Sri Lanka, by conducting a case study in a few coastal areas in the district of Matara which were majorly affected in 2004 by the Indian Ocean Tsunami. Although it has been 15 years since the disaster struck the country, Sri Lanka is still struggling in building back better. This reveals the need to strengthen the action plan toward coastal disaster management by identifying the barriers and challenges that still exist in policies and frameworks, the use of technology in evacuation planning, implementation of evacuation plans and capacity building of the community.

Design/methodology/approach – This study was conducted through structured and in-depth interviews among the general public and government officials targeting the eventual outcome as to ascertain barriers incorporated with the disaster management framework and then possible improvements to the framework were identified and suggested.

Findings – The findings showed that the practice of an administrative-oriented disaster management framework was a key element in creating a welfare-oriented community that is still building back better in Matara, which was one of the worst affected cities in the country during the 2004 Tsunami.

Originality/value – This paper facilitates resilience development by identifying the overall development of the system after 2004. The required modifications needed to strengthen the system have thereby been identified through the developed output which was produced by analyzing the barriers and challenges.

Keywords Resilience, Barriers, Enablers, Tsunami, Disaster management framework, Coastal disaster resilience

Paper type Research paper

This study was conducted with the financial aid from CABARET (Capacity Building in Asia for Resilience Education), a project of the European Union's Erasmus + Programme - Key Action 2 - Capacity Building in the field of higher education.

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflects the views only of the authors, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

International Journal of Disaster Resilience in the Built Environment
Vol. 11 No. 2, 2020
pp. 275-288

1759-5908
DOI 10.1108/IJDRBE-07-2019-0050

1. Introduction

The 2004 Indian Ocean Tsunami (IOT) was one of the deadliest coastal disasters in recent history, resulting in over 230,000 deaths across more than 15 countries ranging across Asia to Africa (Suppasri *et al.*, 2015). The earthquake which generated the tsunami had a magnitude of M_w 9.3, making it the first "extreme" earthquake since the 1964 earthquake (Stein and Okal, 2007, 2005). Sri Lanka was among the countries that were majorly affected, as the tsunami hit at least four-fifths of the country's coastal belt. It caused 29,729 human deaths, displaced 889,175 number of people and over 79,100 houses were destructed (Department of Census and Statistics, 2017; Disaster Management Center, 2018).

Prior to the 2004 IOT, the disasters induced by natural hazards which largely affected the country were floods and landslides, with floods being the major disaster affecting Sri Lankan citizens. As Sri Lanka had not experienced tsunamis in the recent past prior to 2004, the country was woefully unprepared to face such a disaster (Jayasuriya *et al.*, 2006). This was one of the reasons for the high number of losses, as Sri Lanka did not possess any standard tsunami early warning (EW) mechanisms at the time (Siriwardana *et al.*, 2017).

The studies conducted by Burbidge *et al.* (2008), Latief *et al.* (2008) and Jankaew *et al.* (2008) have shown that the return period of a tsunami with a magnitude similar to that of the 2004 IOT will be between 520 to 1,000 years. Yet after the 2004 IOT, several other earthquake-generated tsunamis have occurred in the Indian Ocean, in the years of 2005, 2007, 2010 and 2012. Each of the earthquakes had magnitudes equal to or greater than M_w 8.0 (Suppasri *et al.*, 2015). Since 2004, Sri Lanka was not affected by these tsunamis; hence, the preparation and risk reduction focus on Tsunami risk has decreased compared to the other countries in the region (Rathnayake *et al.*, 2019). However, the knowledge and the awareness of the citizens regarding tsunamis and preparation to face them must be continuously maintained.

The main aim of this research study was to identify barriers and challenges in the disaster management mechanism and to evaluate the context of the affected communities at 15 years after the disaster. Another major focus was given to evaluate the capacity of the whole system to face another disaster of the same kind. The context of the study here is the coastal community that experienced the 2004 Tsunami in the Matara area, which is situated in the Southern Province of Sri Lanka. The term system is used to include the multiple stakeholders in the community, which includes community residents, administrative officers, government processes and non-governmental organizations (NGOs). The affected community, volunteers, divisional secretariat office and other relevant governing organizations are some of the elements of the defined system. The organizations, communities and individuals who do not function during the undisturbed state of the system were recognized as the external elements. Identifying the overall development of the system after 2004 and required modifications to produce an output that facilitates further resilience development in the country was the community contribution of this research study.

2. Methodology

This paper is part of a broader study in analyzing the disaster risk reduction (DRR) process considering tsunamis. It discusses the field observations of the case studies carried out in the Dikwella District Secretariat (DS) Division, which is situated in the Matara District which was heavily damaged by the 2004 IOT. Residents and administrative officials in two Grama Niladari (GN) Divisions, Dodampaha East and Wattegama South, were interviewed. A GN Division is the smallest governing level in Sri Lankan state governance. The interviews were conducted using a structured questionnaire regarding the following four

aspects which were developed to cover and identify the most relevant barriers in the disaster management mechanism; policies and frameworks in DRR, the use of technology in DRR, implementation of evacuation planning and capacity building of the community. The 39 interviewees comprised self-employed personnel, professionals (such as doctors and teachers), farmers and fishermen. Furthermore, administrative officers who have had experience in past disaster events were also interviewed.

3. Policies and frameworks for disaster management in Sri Lanka

Prior to the 2004 IOT, the Reconstruction and Rehabilitation Act No 58 of 1993 existed to provide relief to affected persons, reconstruct property and rehabilitation of victims in the aftermath of a disaster. After the 2004 IOT, a number of legal frameworks were developed, to define and facilitate disaster management in Sri Lanka. In 2005, the Disaster Management Act No 13 was formed. It provided for the formation of the National Council for Disaster Management (NCDM) and the Disaster Management Centre (DMC) (Jayasiri *et al.*, 2018). It is used to govern the disaster management structure in the country. The NCDM was established as the supreme body in disaster management in Sri Lanka (Siriwardana *et al.*, 2018). Figure 1 illustrates the structure of the NCDM (MDM, 2005).

Sri Lanka has also defined other policies and guidelines for disaster management such as the National Policy on Disaster Management, which looks at increasing the country's resilience against disaster risks, the Comprehensive Disaster Management Programme, which provides a comprehensive investment plan to minimize the impact on the citizens' livelihood and the country's economy in the face of a disaster, the National Disaster Management Plan, which looks into reducing the impact of a disaster on various aspects of the country such as communities, infrastructure, economy and development activities and the National Emergency Operation Plan, which provides the Standard Operating Procedures to be used by all associated agencies in time of a disaster (Jayasiri *et al.*, 2018).

In the context of disaster management, the Ministry of Disaster Management (MDM) (MDM, 2019) of Sri Lanka works with a number of inline ministries and organizations in activities of DRR, and it also coordinates with the NCDM. Figure 2 shows the structure of the various departments under the MDM (MDM, 2019). With these overall upstream organizational structures, the DMC acts as the focal point in coordinating lower-level agencies, as illustrated in Figure 3 (Hettiarachchi, 2008). The line departments mentioned here are the Ministry of Health, Department of Irrigation, Forestry Department, Ministry of Defence, Coast Conservation and Coastal Resources Management Department, Ministry of Industries, etc.

When observing the defined administrative processes in Sri Lanka, it is evident that the involvement of external bodies, such as non-governmental and voluntary communities were excluded from the disaster management frameworks. However, their influence and intervention are crucial in disaster management. One such focus area is humanitarian assistance (Rathnayake *et al.*, 2018), as was seen during the aftermath of the 2004 IOT, where over 500 international aid organizations were involved in recovery and rehabilitation work (Silva, 2009). In the course of the study, it was identified that the participation of external bodies such as the armed and police forces had played a vital role during the post-disaster period. Therefore, such external bodies can be identified as major stakeholders in the DRR process. As such, there is currently a discernible gap in linking them to and governing their impact on the DRR process.

During interviews with the administrative officials from the two GN divisions, the officials expressed their discontent at the way their role in disaster management becomes ineffective because of the involvement of external bodies such as the armed forces and

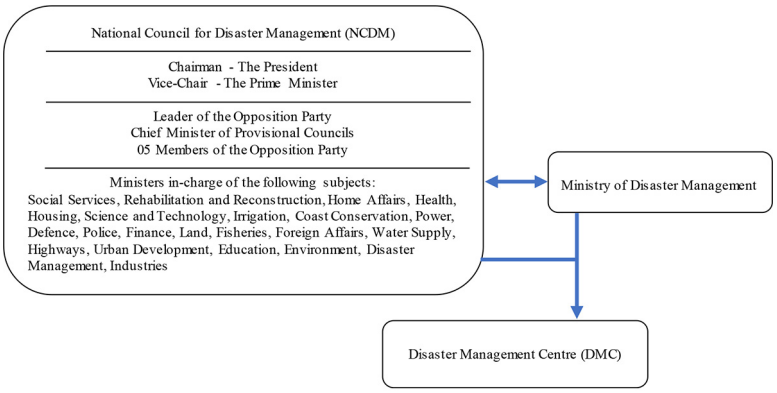

Figure 1.
Structure of the NCDM

Source: MDM (2005)

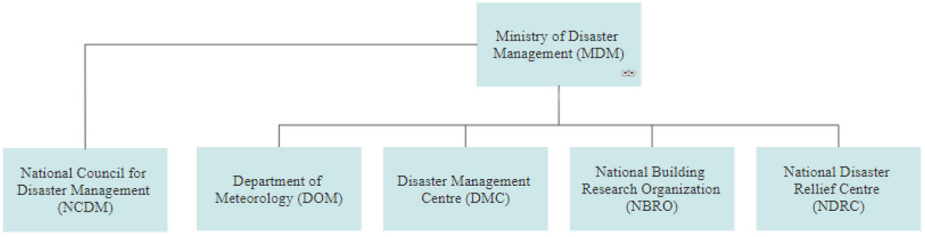

Figure 2.
Organizational Structure of the MDM

Source: MDM (2009)

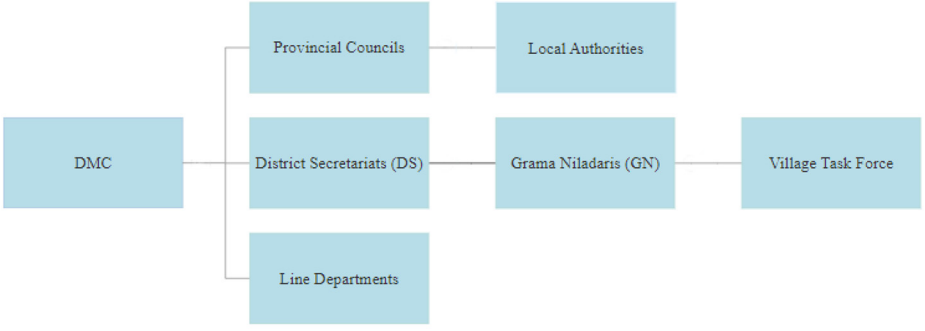

Figure 3.
Coordination between DMC and lower-level agencies

Source: Hettiarachchi (2008)

political influences. This directly showcases the negative impacts because of the gap in the inclusion of helpful external bodies.

Another point of interest is the support gained from private organizations in evacuation planning in terms of technology and monetary aspects. There has been clear disorganization

in the distribution of funds and relief items, possibly because of the lack of inclusion of such funding and relief agencies in the defined DRR process. The administrative process can be strengthened by facilitating increased coordination between such private organizations and the relevant governmental agencies.

Land use planning and resettlement and relocation policies in the administrative process are also major problematics areas (Dissanayake *et al.*, 2018). Many NGOs that participated in building permanent resettlement or restoration of damaged residences for victims displayed a lack of knowledge regarding property rights in the country, resulting in situations such as change of property ownership between spouses (Ruwanpura, 2009). Also, most of these NGOs had put a timeframe of two years for resettlement activities. However, in some parts of the country, victims of the 2004 IOT were residing in temporary shelters for up to 4 years (Mulligan and Nadarajah, 2012).

4. Effective use of technology in disaster risk reduction

The technological advancement over the world has resulted in the development of existing mechanisms to deliver EW alerts toward the vulnerable community level. Different Web-based and mobile-based applications have evolved to make the existing platforms more efficient and convenient for usage by the layperson. These advancements can be incorporated in each stage of the DRR cycle to perform efficient functioning.

During the pre-disaster stage, geographical information systems can be used to generate hazard maps and risk maps to effectively identify and illustrate vulnerable areas during disasters. With these technological advancements around the world, the need of updating the multi-hazard maps in Sri Lanka was identified as a key parameter to enhance the resilience level of the country (Jayasiri *et al.*, 2018). But, the accuracy of the development of multi-hazard maps varies with the return period of each hazard category which is to be integrated with reference to the existing base maps. This can be identified as another research area that can be explored and undertaken under the concept of Multi-Hazard Early Warning (MHEW).

Numerical simulation studies were carried out by researchers to identify the tsunami mitigation measures with respect to structures (Samarasekara *et al.*, 2017). This is already in operation in Sri Lanka under the DMC and multiple line agencies. Global survey technologies combined with computer-aided simulations, big data analysis and database analysis of past disaster incidents can be used to analyze and predict possible disasters and communicate to the government and citizens through MHEW mechanisms. During the disaster and post-disaster phases, technology such as automated drones can be of use in identifying and rescuing trapped disaster victims with minimal danger to rescuers.

Under this research study, a major focus was directed toward the identification of community exposure toward different modes of receiving tsunami EWs and the awareness of modern approaches. The structured interviews with the GN officials and the community revealed that the majority of the community still relies on more traditional modes of receiving EW alerts than on novel digitally enhanced applications. This can be interpreted more in Figure 4.

From the analyzed interview responses, the most preferred mode of receiving tsunami EWs can be extracted as the notification disseminated through the EW towers. This was preferred as the best option by 39 per cent of the responses received.

The DMC has established EW towers in each major town in the coastal zone at prominent places. The EW tower in the Dikwella DS Division has been established in the Dikwella Police Station, as denoted by (1) in Figure 5. During the interviews, the administrative officials revealed that the siren had been audible up to a maximum distance

of 1,000 m during the drills that had been conducted. The audible area is marked from the black circle in Figure 5. The EW tower is 2.83 km away from Dodampahala East GN Division (3) and 432 m away from the Wattegama South GN Division (2). Mobile EW alarm systems (vehicles with sirens attached) are available for other areas.

Next to the warnings given by the EW towers, the majority of the community has shown a preference for the traditional modes of EW. Amongst them, bells or sirens, loudspeakers and TV/radio ranked the highest preferred, exceeding the preference for the modern digital platforms. The low mobile phone and smartphone usage in the community, lack of awareness regarding modern digital platforms and credibility issues of the information received from the other modes can be considered as main reasons behind the interview responses.

Social media platforms such as Facebook and Twitter have ranked as the most efficient modes of delivering EWs in other countries over the world (Collins *et al.*, 2016).

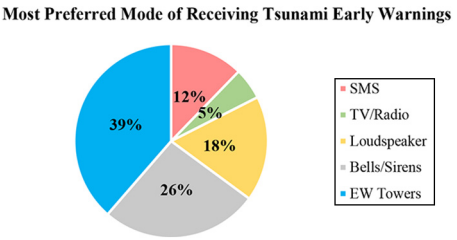

Figure 4.
Community response on the most preferred mode of receiving tsunami EWs

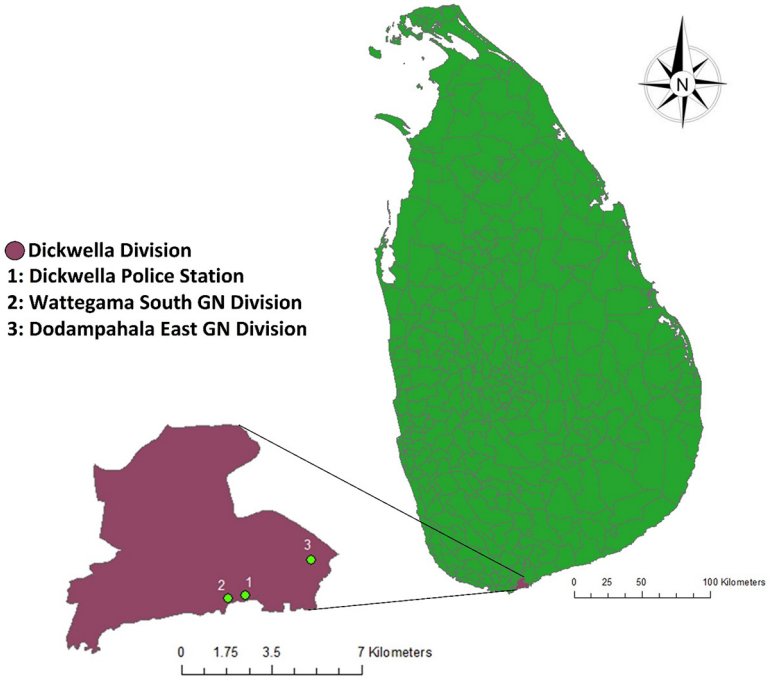

Figure 5.
EW tower location and GN locations in Matara Dickwella

However, when comparing this fact with the obtained data set, the preference for social media when receiving the tsunami EW was almost null. This has revealed that the exposure and the willingness of the community to adapt to new changes are considerably low. The lack of knowledge and the awareness of modern digital communication platforms associated with tsunami EWs can be considered as probable reasons for these community responses.

Short messages service (SMS) is used frequently and has become a trustworthy mode of EW communication in many countries that are highly affected by coastal hazards. Considering the community response of the study location, the receival of tsunami EWs through SMS has been listed as the most preferred method by 12 per cent of the responders.

Another identified platform, which is highly used among the community in other countries is social media apps which enable communication with a larger number of people, especially during and after a disaster. Presently, there are also mobile applications that are being developed for the sole purpose of EW communication and other knowledge dissemination during a disaster. In Sri Lanka, such a mobile application exists, named the Disaster and Emergency Warning Network (DEWN) which was developed by a leading telecommunication company in Sri Lanka and operated by the DMC (Jayasiri *et al.*, 2018). For such services to be fully utilized, the providers need to fully incorporate and integrate the available facilities and technology.

During the study, it was observed that there is a lag in the usage of digitally enhanced communication platforms in the community area of the study. This highlights a lack of exposure and awareness regarding services such as DRR relevant mobile applications. The use of technology at the grass-root level is low, and a significant difference was observed in the technology usage between the younger and older age groups. The elderly population in the community do not show a significant usage of common technology available, whereas millennials do. This tends to be a major drawback in implementing such technologies. One of the initial research findings indicated that 60 per cent of the interview respondents were reluctant to respond to EW messages and 75 per cent of them have no faith in the EWs received.

5. Implementation of evacuation plans

5.1 Disaster evacuation

Implementation of evacuation planning is a key segment that is considered under Coastal Disaster Resilience and Management to minimize the effects of such disasters. In the absence of thorough planning and training, there is the chance of damage and loss occurring that could have otherwise been prevented. For example, during the 2005 Nias Earthquake and Tsunami, about 10 people died due to panic when the evacuation was being conducted from the Sri Lankan coast (Suppasri *et al.*, 2015). Another point to be remembered in DRR planning is that the majority of the victims during disasters such as the 2004 IOT were women and children (Jayasuriya *et al.*, 2006). Therefore, the safety of women and children during evacuation planning should be a priority.

After the 2004 IOT, several training drills had been organized for the general public in each GN division by the government. The DMC frequently organizes EW drills to educate people who live in high hazard potential areas. The main aim of these drills is to make citizens aware of tsunamis and for them to practice skills needed for safe evacuation during a coastal hazard such as a tsunami. From the study, it was gathered that during initial training programs, members of each GN division were divided into groups, with each group being assigned a specific duty during a disaster. These duties included door-to-door disaster

warning and rescue of differently abled and elderly persons. From the results of the interviews, a lack of participation of the general public in EW drills and awareness camps was detected. This means that current public knowledge about coastal disasters and practices used for evacuation planning has slowly reduced.

As part of evacuation planning, the DMC has instructed citizens to prepare and maintain an evacuation pack, which should include their national identity cards, valuable governmental certificates and other valuables and store it in a prominent place. This is so that in case of a disaster or emergency, people can quickly evacuate. However, the interview results indicate that only 18 per cent of the interviewees currently follow this practice.

The study in the two GN divisions revealed that 40 per cent of the residents are reluctant to evacuate from their property during a disaster. One reason for this is because of fear of thievery, as during the 2004 IOT many robberies occurred and the same was repeated during a few past drills. The second reason is the lack of faith in EW systems. This could be partly due to the fact that in the past, a few false alarms had been given. There had also been several instances where training drills had been conducted without informing the public, allowing them to think that an actual disaster would occur. The third reason is the lack of necessary facilities in safer locations.

5.2 Evacuation shelters

The presence of planned evacuation shelters, in addition to providing safe refuge during the disaster, reduces the urgency of rehabilitation and reconstruction, so that those activities can be done in a well-planned and durable manner. When such shelters are poorly planned and insufficient for the evacuated population, the lives of the shelters' residents become difficult, especially those of women's and children's lives. Mulligan and Nadarajah (2012).

In the study area, evacuation shelters are based on a community building in high land. It was observed from the interviews that people tend to take shelters from the nearby temple in Dodampahala East GN Division. The temple has been denoted as the evacuation shelter of the division. There the facilities are the next important factor. Depending upon the time of stay the capacities are determined.

When the community is located more inland, residents deemed it safe to stay in their houses given the assumption that the houses are at a higher elevation. A major example is the Wattegama South GN Division, marked by (2) in Figure 5, which is situated about 500 m away from the coastal line and is at a relatively high altitude. The area does, however, have an evacuation point named by the GN division, which is near a natural rock and the rock has been called the Tsunami Rock.

A major gap identified is that the structural stability and the strength of the structures which are found in evacuation routes such as bridges as well as the buildings used as evacuation shelters for vulnerable communities. These evacuation shelters lack sufficient capacity and basic facilities such as water and sanitary facilities to satisfy all the vulnerable members in the area. Also, another gap identified was that the new constructions of schools and other public buildings are in lowland areas, making them unsuitable to be used as evacuation shelters during coastal disasters.

6. Capacity building of the community

The damage and loss of property, the inward flow of seawater into agricultural land and the destruction of marine life in the ocean made the return-to-career life after the tsunami extremely hard, especially for people involved in trade, agriculture and the fishing industry. Restoration of businesses took 2 months, restoration of agriculture took 6 months and restoration of fisheries took even longer as even after one year, only 40 per cent had been

restored (Suppasri *et al.*, 2015). Out of the interviewees, 32 per cent reported that during the time of the disaster, they had no idea how it would affect their methods of income. From the people who were involved in a career at the time of the Tsunami, 31.5 per cent reported that that they did not return to the same career or started in a different path of work afterward. The people who did resume in the same path reported that they took time periods ranging from a few days to 5 or 6 years to return to work. However, 77 per cent of those people returned to their work by three months after the tsunami.

In terms of immediate post-disaster management after the 2004 IOT, many organizations were involved in search and rescue operations to find those displaced during the disaster. These organizations include the army, navy, air forces and police, staff from local administrative divisions such as the GN and DS divisions, media organizations and NGOs such as the Red Cross organization. The immediate aftermath of the disaster also required the provision of supplies like dry rations, potable water and other supplies. Out of the interviewees, 92 per cent responded that provisions were supplied by NGO's. The government was also involved in providing supplies through the relevant administrative levels.

The IOT caused many damages in the infrastructure systems in the area. The electricity lines were damaged and cut off, the inward flux of seawater caused the water sources to be contaminated and unusable, the transportation systems were blocked off and the public transportation systems were put on hold. From the interview results, the median level of time taken to restore electricity lines was ten and a half days. The time taken to access drinking water without provisions had a median level of nine days. By September 2005, pipeline water provision was restored to all citizens who were served prior to 2004 IOT (Illangasekare *et al.*, 2006). The time taken to restart using the transportation systems after the disaster had a median level of six days for the people in the studied communities.

The damage and losses caused by the tsunami were extensive and costly to the people. The complete replacement of damaged assets was estimated to cost nearly US$2bn (Jayasuriya *et al.*, 2006). The government became involved in various ways to help the affected citizens. The damages and losses were assessed, and compensation and reparations were made to the people in terms of monetary support and equipment supply. Figure 6 shows the satisfaction of the people regarding government involvement during the aftermath of the 2004 tsunami aftermath as a score out of ten.

The government mechanism for re-establishment and restoration of damages and losses for the tsunami affected was as follows. First, the affected person had to file a police

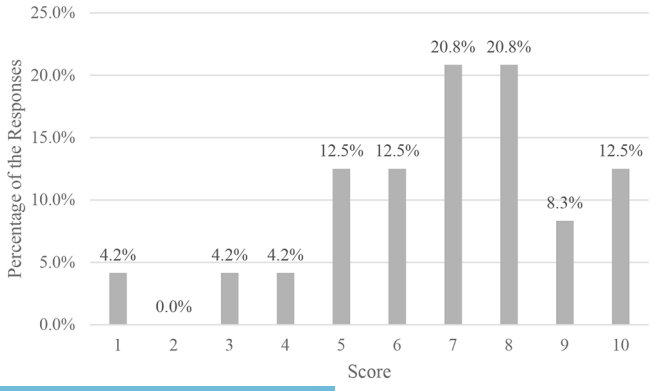

Figure 6.
Satisfaction of governmental involvement during the 2004 IOT aftermath

statement stating the list of damages and losses. Then the government assessed damages and reparations were given in terms of monetary support to build back the losses or a new house or land to resettle elsewhere. Out of the interviewees, 74 per cent reported that at least some physical damage was repaired.

Administrative officers regretfully stated that most of the affected community in Matara, Sri Lanka has evolved into a welfare-oriented culture, where the citizens completely depend on external help to recover from the 2004 IOT disaster. A major observation from the study in Dikwella was that as a whole, the community currently stands at a lower level when compared to its status prior to the tsunami. The citizens have not reached a full recovery state, in terms of the yearly income and household states.

After the Tsunami, a 3-km long retaining wall has been constructed along the coastal line in the Dodampahala area. The coastal line in the study area has been marked as a protected area. However, there have been a series of constructions in that area, mostly hotels and restaurants. While many industries in the coastal zone experienced a downward growth rate following the tsunami, the growth rate of the construction sector increased from 5.5 per cent to 8-10 per cent in the following 3 years after the 2004 IOT (Naik *et al.*, 2007).

7. Concluding discussion

The results of the study conducted in the Dikwella DS Division revealed several significant barriers that prevent the division from attaining satisfactory resilience in terms of livelihood restoration, emergency response and infrastructure capacity after the 2004 IOT. The lack of exposure and awareness of modern technology is a major gap. The administration process has also disregarded indigenous knowledge regarding EW mechanisms such as monitoring of animal behavior patterns prior to the occurrence of disasters.

There is a major drawback in evacuation planning and the interest and participation of citizens in disaster drills and training programs are low. Specific planning for more vulnerable community members such as those with special needs is missing. The residents in the area revealed a lack of knowledge regarding the impact of coastal disasters on aspects such as income methods and critical infrastructure. The available evacuation centers have insufficient capacity and facilities. Also, the construction of potential evacuation centers such as schools and governmental organizations being done in low-land areas reduces the safety of such buildings in the case of a disaster. As mentioned in the section showing the study results obtained regarding the effective use of technology in DRR, lack of faith, knowledge and understanding in EW systems exist in the community. The available EW towers also showcase a capacity inadequacy in reaching all citizens in the area.

The identified barriers have interdependencies and stakeholders (NCDM, local government, community, media, Department of Meteorology [MET], DMC) who have direct and indirect influence and responsibilities over addressing them. Figure 7 has been developed to illustrate this phenomenon in a systematic way.

A major focus was revealed from a recent research study that specially focused on people with special needs (Jayasooriya *et al.*, 2019). This has denoted the lack of preparedness and lack of special mechanisms toward the evacuation of this sector of the population in a coastal community. Further, the barriers in the existing DRR mechanisms linked to EW in Sri Lanka were identified through previous studies (Hippola *et al.*, 2019). These factors should also be addressed to facilitate a better mechanism.

Several barriers in the administrative process of DRR have been identified through this research study as well. There is a lack of policy and a defined process in linking

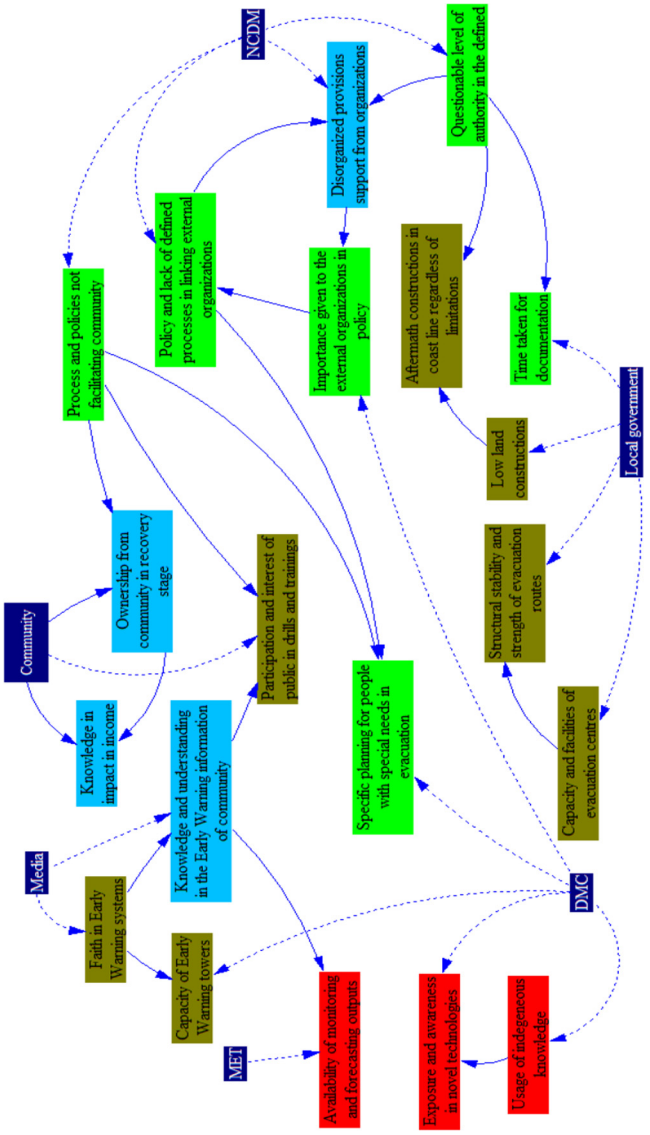

Figure 7.
Barrier network

external organizations to the DRR process. This has led to disorganized provision support from various organizations such as coordination of the media-driven support with the local government processes. The documentation process in the aftermath of the previous disaster had taken a long time, making life even more difficult for the disaster victims. The processes and policies do not facilitate community empowerment, and as such, the community has failed to fulfill the disaster recovery stage. There is a questionable level of authority in the defined administrative process. This has been made evident by the constructions along the coastline in the disaster aftermath, which has been done disregarding the non-construction zoning policies implemented by the government in those areas.

When constructively observing these barriers, four major attributes can be identified:

(1) Not all existing barriers are tangible.

(2) There is a repetition of the same gap in various context.

(3) The main responsible authority or stakeholder of barriers can vary or remains the same.

(4) Some barriers are a result of cascading of another gap.

Figure 7 shows the process barrier network developed. Community, media, NCDM, local government, DMC and MET were the identified elements/institutions that have major links with the barriers identified from the study. It illustrates the cascading nature of every gap and how each of the intuitions is linked with the barriers. It can be used to identify the stakeholders to address the barriers. The use of this process will be valuable in all levels of decision-making. A gap prioritizing and clustering or ranking can be done using this network diagram methodology.

Often, a disaster caused by natural hazards has the propensity to escalate to disaster level because of existing political and economic conditions in the area (Pelling, 2001). Therefore, to minimize future damage and increase resilience, it is imperative that both the administration and community work together to establish a prepared and knowledgeable community.

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