THE CURRENT CONTEXT OF MULTI-HAZARD EARLY WARNING SYSTEMS (MHEWS) FOR COASTAL RESILIENCE AT NATIONAL LEVEL

Sri Lanka

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1. Executive Summary

CABARET aims to build capacity for international and regional cooperation between Higher Education Institutes (HEIs) in Asia (region 6) and Europe, and among Asian HEIs themselves, to improve Multi Hazard Early Warning (MHEW) and increase disaster resilience among coastal communities. To contribute this valuable project, Sri Lanka prepared this National Position Paper in order to identify the existing situation of MHEWS in the country with respect to coastal communities.

After carrying out a through literature review and interviewing key personnel related to the Disaster Management and Disaster Risk Reduction sector, existing conditions were identified with relevant to coastal hazards, multi hazard assessments, global initiatives, national efforts, regional cooperation, resilience mechanisms and the role of Higher Education Institutes regarding the MHEWS for the coastal zone in Sri Lanka. The literature review was done by going through all the available plans, programmes and other articles related to disaster management in Sri Lanka. Additionally it was strengthened by referring to the research papers published both locally and internationally. During the interview process, eleven key personnel were interviewed including four academic members, six government officials and one from a non-government organization.

During the literature survey, it was observed that Sri Lanka has developed a Hazard profile for the country and an Multi hazard Early Warning Dissemination System exists as well. The impacts of the coastal hazards to both the coastal infrastructure and the communities is significant. Indian Ocean Tsunami was the major disaster which made a considerable damage even though it's return period is high. Economic loss, displacement of the coastal communities, effect on the water quality, loss of habitats in estuaries, drought and salt-water intrusion, loss of coastal properties, damage to the population, and rapid loss of land are some of the critical impacts to the coastal belt of Sri Lanka. At present country has done only one multihazard assessment, which is outdated now. Furthermore, the country is in the process of aligning the existing policies, which were prepared by referring to the Hyogo framework, with the post 2015 global standards.

When looking at the regional efforts on MHEWS, Sri Lanka is a member of IOTWMS and RIMES. Sri Lanka has also given training related to coastal zone management to other countries like Myanmar as well. In addition, participation of the government agencies in international events related to disaster management to share knowledge and gather information as well as new technologies is appreciated. Even though the country lacks of proper and efficient resilience mechanisms focused on the coastal communities, national efforts are under way to build up the coastal resilience. National Insurance Trust Fund is one of the key mechanisms to provide rehabilitation and compensation money to the victims during a disaster. Disaster Management Act, National Disaster Management Policy and other disaster management plans act as the driving documents of coastal resilience in Sri lanka. In addition, coastal zone management plan prepared by Coast Conservation Department specifically focuses on disaster risk reduction of the coastal belt in the island.

Contribution of the Higher Education Institutes in research work as well as for international programs are significant. Training and public awareness campaigns, efficient funds, properly maintained hierarchy and concern to the coastal eco systems are some of the enablers associated with MHEW in coastal resilience. Mismatch of expectations of the stakeholders and lack of participation in the awareness programs are some of the barriers HEIs face in their role of MHEWS.

In general, after analyzing the information gathered, following conclusions and recommendations were made to improve the status of the multi hazard early warning systems for coastal resilience in Sri Lanka.

- A community based Multi Hazard Early Warning System is necessary to increase the coastal resilience of the country. For proper operation and efficiency Identifying the impacts of coastal hazards at all levels, enhanced inter-agency cooperation and the use of advanced technology is important.
- Improving the data availability for investigating, forecasting/predicting and managing risks on different time scales and introducing mechanisms for sustaining the early warning dialogue and supporting the development is also necessary
- Current National policies and frameworks related to coastal hazards must be aligned to the post 2015 global frameworks quickly as possible to reach the global targets in time
- Higher Education Institutes must involve more in Cross-disciplinary and transdisciplinary research and awareness campaigns to build the coastal resilience while sharing their expertise in addressing the complexities of coastal resilience

2. Introduction

CABARET aims to build capacity for international and regional cooperation between Higher Education Institutes (HEIs) in Asia (region 6) and Europe, and among Asian HEIs themselves, to improve Multi Hazard Early Warning (MHEW) and increase disaster resilience among coastal communities. In doing so, CABARET focuses on a subject area and a world region not sufficiently addressed by projects already being funded under previous schemes.

CABARET will address the cognitive and normative challenges in positioning early warning and preparedness in the wider trajectories of social change in societies and communities at risk. It is an imperative to take an integrated and holistic approach to early warnings for multiple hazards and risks tailored to user needs across sectors. In order to do this, first, partner institutions in each country will conduct a literature review at national level. The literature review mainly involves a review of current available policies, guidelines, national/local reports (e.g. White papers, if any), action plans, etc. to detail mainly the following:

- List of actions/initiatives, including, but not restricted to, policies, guidelines, national/local reports action plans, etc., for MHEW in coastal resilience taken at national/local level to improve MHEW and increase disaster resilience among coastal communities.
- Outcomes of the aforementioned actions/initiatives.
- Key stakeholders in MHEW in coastal resilience at national/local level in each country.
- Current enablers in MHEW in coastal resilience.
- Challenges associated with MHEW in coastal resilience.
- Role of the HEIs in the Country in improving MHEW in Coastal Resilience.

This report discusses the above in the view of Sri Lanka. The relevant discussions are given in Sections and Sub-sections below.

3. Methodology

A thorough literature review was carried out initially to identify the status of the Multi Hazard Warning Systems in Sri Lanka by doing a literature survey. In Sri Lanka, most of the plans, policies made by Disaster Management Centre (DMC) and Ministry of Disaster Management (MDM) are available online with free public access. Early warning systems, coastal hazards, disaster management, disaster resilience, coastal resilience, community resilience and climate change are some of the key words used during the literature survey. After downloading the related documents, they were analysed further by going through executive summaries, introductions and abstracts to check the alignment with the requirements of the research. Then the Data collection was done by interviewing key professionals who are actively involved in Disaster Management (DM) activities and academic staff of Higher Education Institutes (HEI). Out of the fifteen participants selected only eleven participated, where each of them were presented with a Questionnaire followed by a discussion. The interviewers noted down the key points mentioned by the experts. A thematic content analysis method was to analyse the gathered data.

Table 1: Participant Details

Participant Code	Level of experience in terms of involvement in MHEW in Coastal Resilience	Any other Remarks
SIA01	A Senior Professor at the Department of Agricultural and Plantation Engineering, Open University of Sri Lanka who has involvement in coastal flooding	Open University offers several courses related to Agriculture and Plantation (Some coastal areas have paddy cultivation)
SIA02	A Senior Professor at Department of Sociology ,University of Colombo who has experience in social aspects related to coastal community	Sociology Department is involved in most policy making activities in Sri Lanka
SIA03	A senior lecturer in the field of sustainability in National School of Business Management (NSBM)	NSBM is one of the private sector universities in Sri Lanka
SIG04	The current media spokesperson of DMC who is actively involved in MHEW in coastal resilience	DMC is one of the main bodies in Sri Lanka which issue early warnings.
SIL05	The Director General of the Department of Meteorology (DoM)	DoM is responsible in issuing weather forecasts and issue early warnings
SIL06	The Chief Engineer of Coastal Research & Design Division in Coast Conservation and Coastal Resources Management Department (CCD)	CCD is mainly responsible for issuing early warning in Oil spills in the

SIG07	The Director (Mitigation,Research & Development) of the Disaster Management Centre	She is responsible for the research work carried out in DMC
SIA08	The Emeritus Professor working in the Department of Physics in University of Peradeniya involved in Disaster Management	Involved in the Masters programme of Disaster Management
SIL09	The Head - Human Settlements of National Building Research Organization	NBRO acts as the main body which issues land slide early warnings and building guidelines
SIP10	The head of IUCN – International Union for Conservation of Nature	He is involved in several eco system based risk reduction work
SIL11	The Senior environmental professional-water resources management of National Building Research Organization	NBRO acts as the main body which issues land slide early warnings and building guidelines

4. Background

Sri Lanka is a South Asian island in the Indian Ocean, southeast of the Indian subcontinent between latitudes 5° and 10°N, and longitudes 79° and 82°E, in a strategic location near major Indian Ocean sea lanes. It has a total area of 65,610 km², with 64,740 km² of land and 870 km² of water. Its coastline is 1,340 km long.

The south-central part of Sri Lanka (the rugged Central Highlands) is the heart of the country. The core of this area is a high plateau, running north south for approximately 65 kilometers. This area includes Sri Lanka's highest mountains. The highest point is Pidurutalagala, reaching 2,524 meters above sea level. Most of the island's surface consists of plains between 30 and 200 meters above sea level. A coastal belt about thirty meters above sea level surrounds the island. Much of the coast consists of scenic sandy beaches indented by coastal lagoons. In the Jaffna Peninsula, limestone beds are exposed to the waves as low-lying cliffs in a few places. One of the world's best natural harbors is at Trincomalee on the northeast coast, and a smaller rock harbor is at Galle on the southwestern coast.

Sri Lanka's climate can be described as tropical, and quite hot. The average temperature ranges from a low of 16 °C (60.8 °F) in Nuwara Eliya in the Central Highlands to a high of 32 °C (89.6 °F) in Trincomalee on the northeast coast. Rainfall pattern is influenced by monsoon winds from the Indian Ocean and Bay of Bengal. The "wet zone" and some of the windward slopes of the central highlands receive up to 2,500 millimeters (98.4 in) of rain each year, but the leeward slopes in the east and northeast receive little rain. Most of the east, southeast, and northern parts of Sri Lanka comprise the "dry zone", which receives between 1,200 and 1,900 mm (47 and 75 in) of rain annually

The arid northwest and southeast coasts receive the least amount of rain at 800 to 1,200 mm (31 to 47 in) per year. Periodic squalls occur and sometimes tropical cyclones bring overcast skies and rains to the southwest, northeast, and eastern parts of the island. Humidity is typically higher in the southwest and mountainous areas and depends on the seasonal patterns of rainfall. An increase in average rainfall coupled with heavier rainfall events has resulted in recurrent flooding and related damages to infrastructure, utility supply and the urban economy. (Briney, 2017)

The estimated Mid-Year population of Sri Lanka is 21.2 million in 2016 (an increase of 2, 37,000 people compared to the previous year). Highest population of 2.4 million is reported from Colombo district whereas lowest is reported from Mullaitivu district (Ministry of Home Affairs, 2017).

5. Coastal Hazards

Coastal erosion, drought, floods, sea level rising, storm surges, tropical cyclones and Tsunamis and oil spills are some the coastal hazards common to Sri Lanka. The main characteristic of the coastal multi-hazard approach is the variability of the return periods associated with each type of hazard. When considering Sri lanka, erosion and a storm surge triggered by the monsoon have an annual return period, multi centennial storm surges triggered by cyclones are multi centennial and a major tsunami can be even multi cen- tennial to millennial.(Garcin et al., 2008)

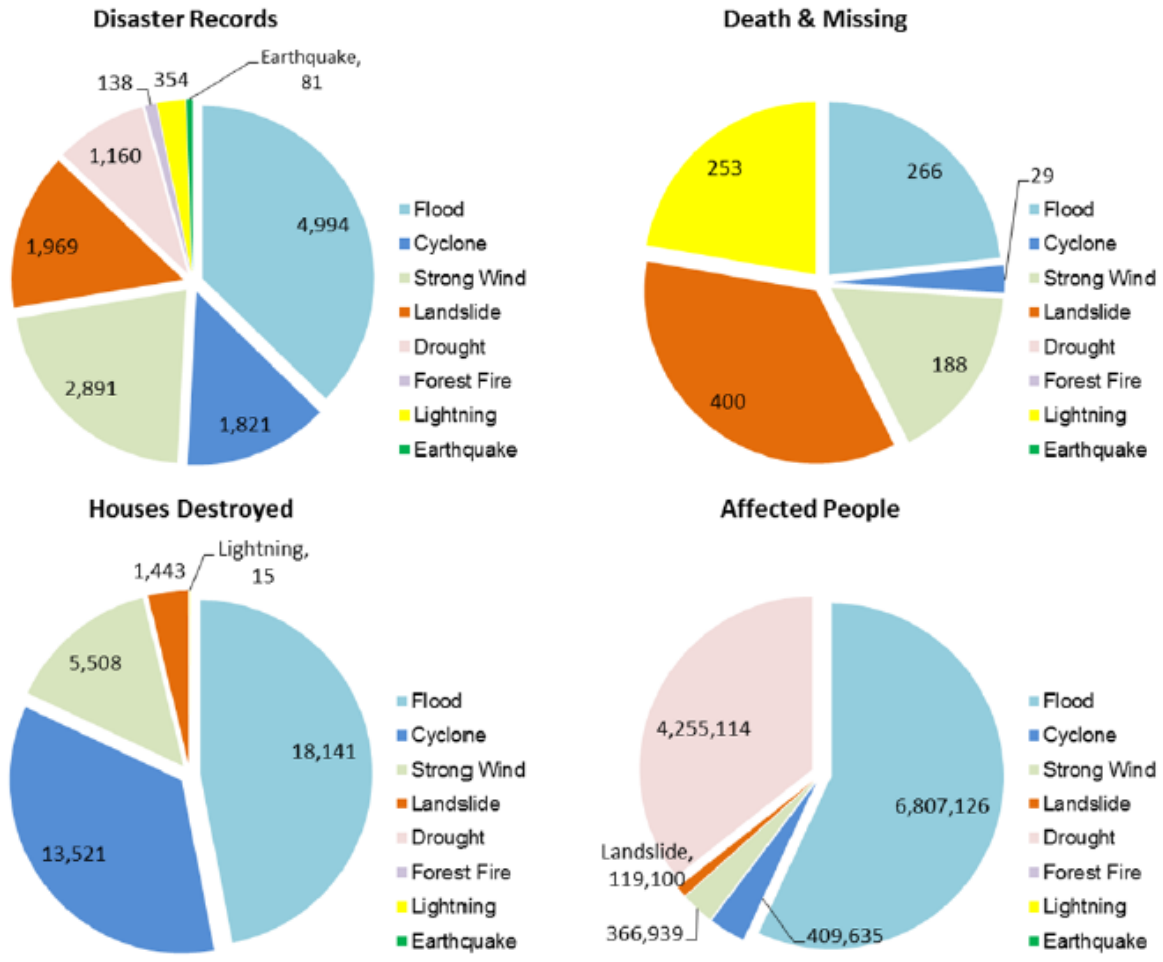


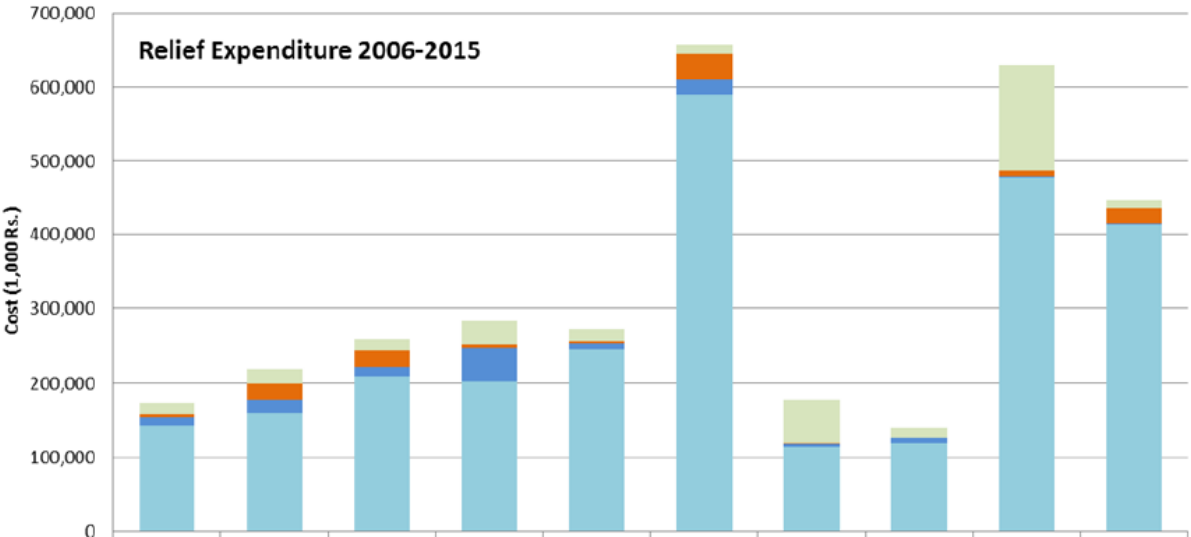
Figure 1: Disaster records from 2006-2016 (Japan International Cooperation Agency, 2017)

The Indian Ocean Tsunami, which hit Sri Lanka on 26 December 2004, was the major coastal disaster, which caused 39,143 deaths while it affected 800,000 people in the coastal zone. It also had widespread effects on Sri Lanka's environment and ecosystems(Helgeson, 2005). Colombo floods, which occurred in May 2016, and the floods in 2017 caused major damages making the city of Galle where 142,149 people (36,314 families) have reportedly been affected(Relief Web, 2017). Salinity intrusion in Colombo and Gampaha districts is also a major concern with respect to coastal hazards (unicef, 2017).

5.1 Impact of the Coastal Hazards

5.1.1 Literature Review findings

When considering the impacts of the disasters in Sri Lanka Coastal hazards combined, has a significant impact to the coastal communities as well as to the country as a whole. The distribution frequency of the events, number of people affected, and loss of life due to disasters throughout the islands clearly shows that coastal communities are the most affected (Disaster Information Management System, 2012). Relief expenditure of the country also has an increasing trend (Ministry of Disaster Management, 2014). Furthermore, during any year the relief cost for flood disaster accounts for approximately 80% to 90% of the annual expenditure. Relief expenditure (Figure 2) for past decade clearly shows the impact of the disasters to the communities. In addition, compared to the population growth rate, people affected by floods has a higher increased rate(Japan International Cooperation Agency, 2017).



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Drought	15,194	19,922	15,287	31,139	16,308	12,864	58,563	12,049	140,826	11,072
Landslide	4,636	22,587	20,503	4,929	3,253	34,398	672	181	9,788	21,959
Cyclone	10,237	17,662	11,676	43,880	8,678	20,997	3,845	8,293	1,506	541
Flood	143,309	159,111	210,339	202,680	244,091	589,836	113,942	118,425	476,284	413,129

Figure 2: Trends of disaster relief costs in each disaster from 2006 to 2015 (Japan International Cooperation Agency, 2017)

Furthermore, saltwater intrusion in coastal areas due to over extraction of water from tube wells, risk of sea level rise and increased frequency of storms have major impacts on coastal ecosystems that support the marine food fishery. The 2004 Tsunami destroyed many of the tube wells in the coastal areas of Sri Lanka (Illangasekare et al., 2006). Impact of the Tsunami on fisheries and coastal livelihoods in southern Sri Lanka is also significant as it crippled the Tuna processing industry and the fishing fleet (De Silva and Yamao, 2007). In addition, dumping of garbage in lagoons and estuaries and unsustainable fishing practices are some of the man-made hazards, which can cause degradation of coastal eco systems (Silva, 2016).

5.1.2 Interview and Focus group findings

According to the findings from the interviews, following impacts from coastal hazards were identified.

- Economic loss
- Displacement of the coastal communities
- Effect on the water quality
- Loss of habitats in estuaries
- Drought and salt water intrusion
- Loss of coastal properties
- Damage to the population
- Rapid loss of land

When considering the above impacts it is visible that handling coastal hazards at both local and national levels is important.

Table 2: Importance of handling coastal hazards

National Level	Local Level
• Can issue early warnings effectively and accurately for the people to evacuate in time • By introducing proper policies, plans and legislations can protect the coastal belt to protect it from natural hazards as well as from man – made hazards • By reducing the associated risk by handling coastal hazards properly the tourist attraction will be increased as well as the economy of the country • Can introduce advanced technology to the country in the perspective of coastal hazards which will also assist the research and development work with respect to coastal hazards • To make coastal communities aware about the hazards which they are vulnerable • To develop proper guidelines to handle coastal hazards	• To understand the vulnerability of the hazards in the respective local community • To evacuate and go for shelter during a disaster to reduce the loss of lives • To build resilient infrastructure and manage existing private properties to reduce the vulnerability for a disaster • Fishermen, in local communities can get early warnings in time for them to not to go fishing during a storm surge or any coastal disaster. • To choose the profession carefully by studying the hazards in the respective community in order to obtain a greater profit. • To identify proper evacuation routes • To conserve natural habitats

5.2 Early Warning Systems available for Coastal Hazards

5.2.1 Literature Review findings

According to the EW framework, when there is an impending disaster, the technical agency responsible for the given hazard determines the scale of the disaster and the decision is conveyed to the MDM and the Emergency Operation Centre (EOC) of DMC. In Sri Lanka MHEWDS is available as a whole without being specifically focused on coastal hazards(Jayaweera, 2012)

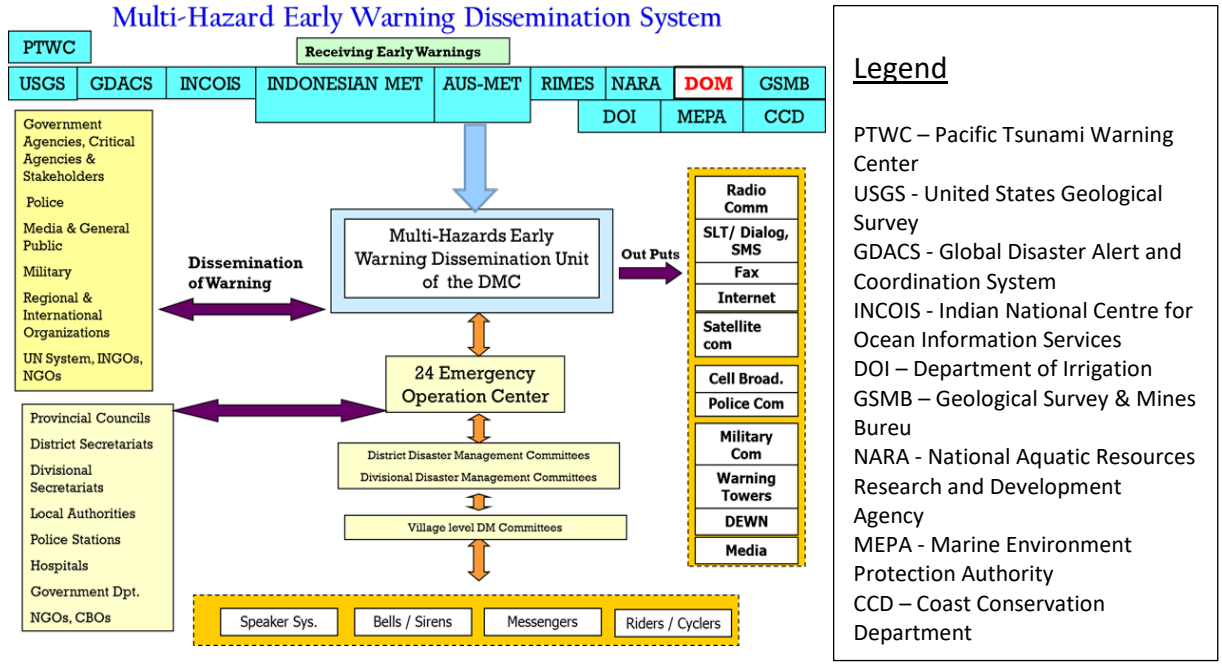


Figure 3: Multi Hazard Early Warning Dissemination System (The World Bank, 2014)

Each organization must ensure and confirm the delivery of the early warning messages up to their last mile branches. Dissemination of warning from national level to the grassroots level is divided into four layers, namely, National, District, Divisional and GN Level. The Emergency Operation Center (EOC) of the DMC receives the EW message from International and Regional Technical Agencies. Then a national level EW message is disseminated to the emergency response committees, as they have to pass the messages to their own organizations. District Disaster Management Centre Units (DDMCU) disseminate the district level EW messages to the District Secretariat and stakeholder agencies. DDMCUs also disseminate Divisional level EW messages to the divisional secretariats. Finally, GN level EW message is disseminated to the vulnerable community by last mile communication tools (Disaster Management Centre, 2015a)

DMC must confirm the proper working of the early warning system and ensure the reception of the warning up to the grass root level. DMC must confirm the ground level information and clarify with the technical agencies whether the information is valid to address a disaster (Jayaweera, 2012).

Following organization are technical agencies responsible for issuing early warnings for coastal hazards

- Department of Meteorology - Cyclones, Tsunami, storm surges, drought
- Department of Irrigation – drought
- Coast Conservation and Coastal Resources Management Department – oil spills
- Marine Environment Protection Authority – maritime hazards

Furthermore, National Emergency Operation Plan highlights the coordination network of the line agencies during a disaster to issue early warnings effectively as shown in Figure 4.

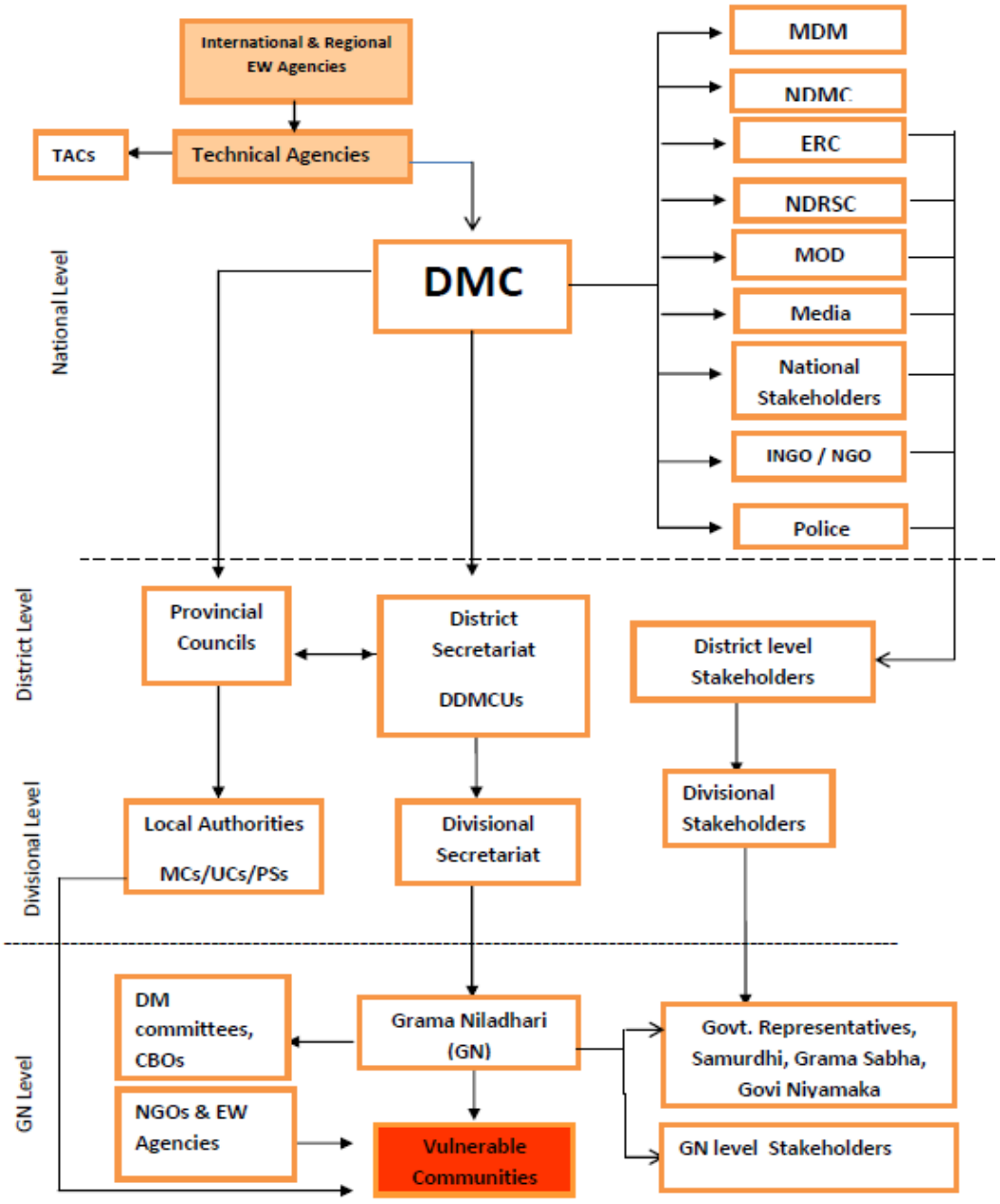


Figure 4: Early Warning Coordination Network (Disaster Management Centre, 2015a)

In Sri Lanka Early Warning messages are based on five stages namely Alert, Warning, Evacuation order, Withdrawals and Stand down. The threshold levels of various technical agencies during early warning mechanisms are mentioned in the table below (Disaster Management Centre, 2015a).

Table 4: Threshold levels for different hazards in Sri Lanka

Hazard	Threshold Level
Tsunami	The lower boundary can be identified as the time at which the earthquake occurred
Flood	Time at which the water level reaches the flood level in rivers or reservoirs declared by relevant identified technical agencies
Landslide	Time at which the rainfall received reaches the saturation level.
Cyclone	Alert level of a cyclone can be defined well in advance by predicting the expected path of the cyclone. Boundary for alert is set 72 hours before the cyclone enters into Sri Lankan coast
Drought	Slow on-set; duration may vary depending on the terrain, environmental condition and geographical area, etc.

Media plays a prominent role during the dissemination of early warnings in Sri Lanka, covering the entire island easily through television and FM radios with more than 50 channels. In addition, DMC has direct coordination with military and police to disseminate the early warning messages to vulnerable communities. Military and Police posts are located in many areas in the entire country (Disaster Management Centre, 2015a).

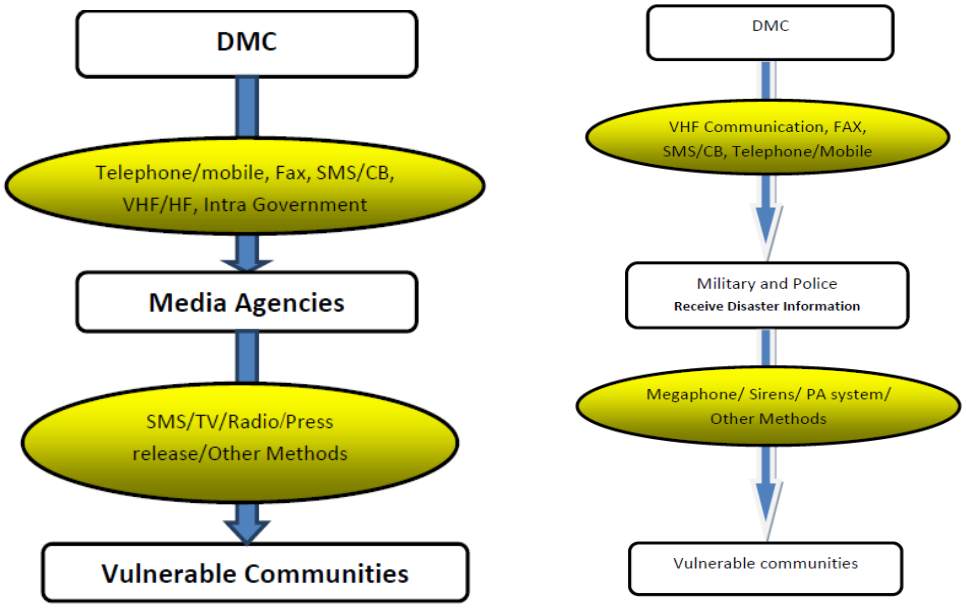


Figure 5: Role of media (Left) & Role of Military & Police (Right) (Disaster Management Centre, 2015a)

5.2.2 Interview and Focus group findings

When analyzing the interview findings it is visible that most interviewees know there is an early warning system for Tsunamis but for other coastal hazards there aren't any specific early warning systems.

> 'Except for Tsunamis there are no early warning system for coastal hazards' (SIL06)

According to SIG04 following integrated methods are available as early warning measures from national level up to the grass root level.

Table 5: Early Warning dissemination methods

National Level & District Level	Village Level
• 77 Early Warning Towers. • Police & Military Communication • Cell Broadcast/ SMS • Intra Governmental Network (IGN) • Satellite & Radio Communication) • Telephones / CDMA/ GSM • Radio Communication(HF & VHF • Telephones/Fax / CDMA/ GSM • Police & Military Communication • Media	• Telephones / CDMA/ GSM • Police Vehicles – Announcements • NGOs and CBOs • PA Systems with relevant agencies. • Sirens (Hand and Electric) • Temple and church bells • Riders/ Push Bicycle & Motor Cycles/Messengers • SMS / Cell Broad cast • Early Warning Towers • Media • Traditional and Religious methods • Early Warning Committees (Door to Door)

Importance of early warning systems for coastal hazards are mentioned below.

- To avoid or reduce the impact of coastal hazards
- Developed early warning systems that can be managed by local communities will have long-term sustainability built into their design and operation
- To build the capacity of communities to benefit from early warning systems, and to integrate this knowledge into their livelihoods and wellbeing to reduce risk
- To use the locally available techniques and methods effectively to manage village level early warning systems which will also increase the knowledge of the local communities

6. Multi Hazard Assessments

Currently there are no any specific multi hazard assessments being done for the coastal hazards in Sri Lanka. But in the National Policy of Disaster Management under the section "Multi-dimensional approach" it has been highlighted that multi hazards should be given consideration (National Council for Disaster Management, 2010). At present individual natural hazard mapping & assessments are finalized and hazard profiles for coastal erosion, floods, drought, sea level rise, storm surge, tropical cyclones and Tsunami were produced (Disaster Management Centre, 2012).

6.1 Literature Review findings

During the year 2006 a team of researchers carried out a hazard mapping and identifying risk spots of Sri Lanka as a whole. They were able to produce a multi hazard map for the whole country by aggregating the individual hazard indexes for droughts, floods, cyclones, and landslides, with weighing hazards in different ways (Zubair et al., 2006).

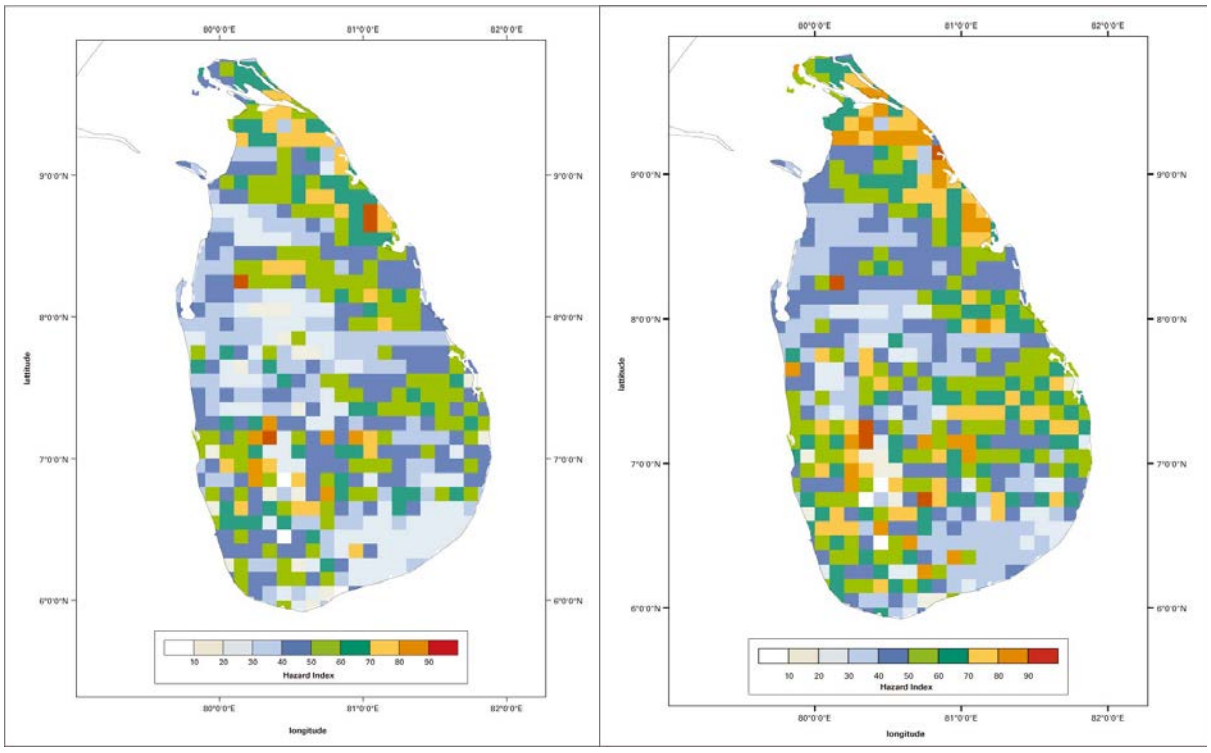


Figure 6: Multi Hazard Maps, Equally weighing hazards (Left) & by incident frequency (Right) (Zubair et al., 2006)

Furthermore, after the 2004 Tsunami disaster in Sri Lanka a prototype of a Coastal Hazard GIS is prepared for the city of Galle in order to assist the decision makers to limit the impact of natural coastal hazards such as sea level rise, tsunamis, storm surges and coastal erosion, to protect the exposed assets (Garcin et al., 2010). In addition, GIS based flood risk analysis is done for a 50 year rainfall to develop an information systems for flood forecasting in the Kalu

river (Samarasinghe et al., 2010). Another flood hazard mapping was done for the lower reach Kelani river basin (Gunasekara, 2008). Sri Lanka's exposure to seismic, volcanic and tropical storm hazards were evaluated by United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and a multi- hazard map was developed which can be accessed at http://preventionweb.net/go/4152 .

6.2 Interview and Focus group findings

All interviewees mentioned that according to their knowledge hazard assessments for coastal hazards have been carried out. They referred to the Tsunami hazard assessments mostly. SIL06 mentioned that coastal risk assessments were carried out in collaboration with international organizations. According to SIG04 hazard mapping is completed which includes the coastal hazards as well which can be accessed at http://riskinfo.lk/. In this website they have identified the population within 500m of Tsunami inundation zone.

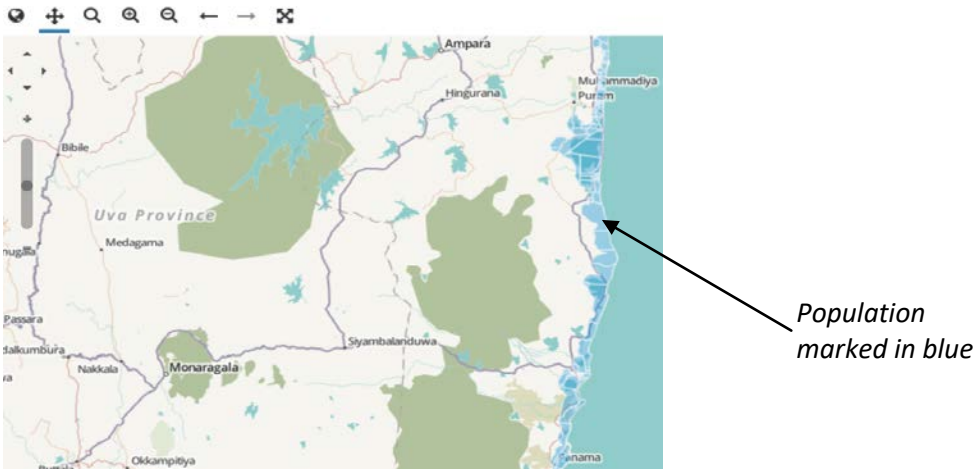


Figure 7: Population within 500m of Tsunami inundation zone in Eastern Province (Source: http://riskinfo.lk/)

In addition, SIG04 mentioned that DMC and relevant technical agencies at National level carry out the hazard assessments. Most interviewees mentioned that Sri Lanka has the capacity to carry out the hazard assessment work but what lacks is the advance modelling software. Hence, most authorities work with the international agencies to carry out the assessments. It was also highlighted that Sri Lanka has the capacity to give training and consultancy on hazard assessments for other countries where SIL06 had given training to Myanmar. Furthermore, SIL09 mentioned that hazard maps for selected districts are available in http://www.nbro.gov.lk/

Furthermore, SIP10 mentioned that they have developed a mechanism and a technical approach to rebuild ancient tank-cascades in dry zone to address droughts and floods, as a model. SIP10 also had done a hazard assessment and resilience plan for the Delft Island as well.

7. Global Initiatives on Multi Hazard Early Warning (MHEW) Systems

Before 2015, Sri Lankan government has taken necessary actions to amend the relevant Disaster Management (DM) plans and programmes to Hyogo Framework for Action (Prevention Web, 2015). At present, the country is in the phase of aligning the national policies and programmes with post-2015 global frameworks such as the Sendai Framework for Disaster Risk Reduction, Paris Climate Change Agreement and Sustainable Development Goals. In addition, according to the Asia Regional Plan(UNISDR, 2016), which guides the implementation of the Sendai Framework, national policies should seek to align to the Sendai principles; placing special emphasis on coherence and integration with international agreements for development and climate action. In order to do proper amendments professionals are in the process of evaluating existing DM frameworks in Sri Lanka.

7.1 Literature Review findings

According to the Sendai Framework data readiness review(Prevention Web, 2017) Sri Lanka is planning to have Multi hazard monitoring and forecasting systems at the beginning of the year 2020 which refers to the Global target G of the Sendai Framework. In addition, capacity, resources and proper technology is needed to establish MHEWS. Even though the Paris Climate Change Agreement was signed by Sri Lanka on 22 April 2016 ,the impacts of climate change to hazards were considered in the Comprehensive Disaster Management Programme (Ministry of Disaster Management, 2014). Following stakeholders are involved in the implementation process.

- National Council for Disaster Management
- National Disaster Management Coordination Committee
- Ministry of Disaster Management
- Disaster Management Centre
- National Disaster Relief Services Centre

When analyzing the achievements compared to international frameworks, the progress evaluation of HFA, disaster management organizations and systems have been established in each country based on PA1 and disaster response systems including early warning systems have been strengthened based on PA5 (Japan International Cooperation Agency, 2017). Furthermore, the efforts taken by the Sri Lankan government to implant the successor of Hyogo framework: The Sendai framework shows that the National Action Plan must incorporate several targets and polices to align with the priority actions (Japan International Cooperation Agency, 2017).

In order to monitor Sendai Framework and to achieve the Global Target (e), the Ministry of Disaster Management suggests that the draft National Action Plan must indicate amendment of National Disaster Management Plan (NDMP) and re-develop Sri Lanka Comprehensive Disaster Management Programme (SLCDMP). In addition, regarding implementation of PA3:

"Investing in DRR for Resilience", promotion of mainstreaming of DRR seems higher priority than creation of new investments to DRR (Japan International Cooperation Agency, 2017).

7.2 Interview and Focus group findings

It was identified that some of the interviewees are not aware about the Sendai framework and other post 2015 global frameworks. SIL06 mentioned that they are not much involved in implementing these initiatives. At present Disaster Management Centre (DMC) is responsible for implementation of these frameworks and Ministry of Disaster Management is responsible in increasing the disaster resilience among coastal communities.

When looking at the integration of these frameworks in order to improve MHEW and to increase disaster resilience among coastal communities, interviewees mentioned that it is at a minimum, but provisions exist. In addition, SIG07 mentioned that stakeholder discussion is going on the mandated activities while the baseline surveys are going on the reporting purposes.

After the discussion importance of implementing global initiatives for MHEWs in coastal hazards were identified as mentioned below.

- By aligning with global initiatives as a country Sri Lanka will be able to get the required assistance in funding and technical support to establish an effective MHEWS for the coastal zone.
- Can get the expert advises when required easily
- Can bring the existing Early Warning Systems to the required standard by following the guidelines
- To bring the morale of the vulnerable communities up to become disaster resilient by informing them Sri Lanka is following the global standards

8. Current National efforts towards MHEW in Coastal Resilience

8.1 Literature Review findings

At present Sri Lanka has been able to produce the national hazard profile for the whole country. With respect to the coastal resilience, hazard profiles are developed for coastal erosion, floods, droughts, sea level rising, lightning, storm surges, tropical cyclones and Tsunamis (Disaster Management Centre, 2012).

Table 6: Hazard data and mapping methodologies

Hazard	Data and mapping methodology
Coastal Erosion	A tailored methodology was used with the fuzzy logical approach. Local expertise was also taken for the erosion assessment. After identifying coastal sedimentation cells three drivers of wave incidents namely; angle, sediment balance and shoreline geometry were considered in the erosion assessment model. Increasing the reliability of wave data, calibrations must be done to maintain accuracy.
Floods	Digital Elevation Models and ground surveys were used for simulations. Then for a given rainfall or inflow pattern inundation can be obtained.
Droughts	14 indices were used considering Agro Ecological Zones as the spatial units. Factor analysis was done using SPSS software. Hazard map was produced using time series of rainfall and evapotranspiration data.
Sea level rising	High resolution LIDAR topographic data and ASTER data were used to establish the Digital Elevation Model. The Modelling was carried out in Geographic projection with WGS 1984 datum. After producing the hazard map it was noted that areas, which were not covered by LIDAR survey have a low accuracy
Storm surges	Topographic and bathymetric data and records of past cyclone events were considered when building the model. For validation field observations of water levels due to past cyclones were considered. MIKE 21 flow model was used to predict the sea surface elevation due to cyclone induced wind and pressure fields. Then by considering several cyclone hazard scenarios hazard maps were produced
Cyclones	The data on cyclones from 1881-2011 were collected from DoM. Non-hydrostatic Meso-scale Model (NMM) dynamic core of Weather Research and Forecasting (WRF) model was used to prepare a wind hazard map for the country.

Lightning	Thunder days observed by 20 stations allocated to DoM from 1961-1990 were used to generate the hazard profile by considering two phenomena monthly and yearly variations.
Tsunami	The numerical model COMCOT was used to stimulate transoceanic Tsunami propagation and subsequent inundation in coastal areas. For the validation of the model field measurements of water levels of 2004 Tsunami was considered.

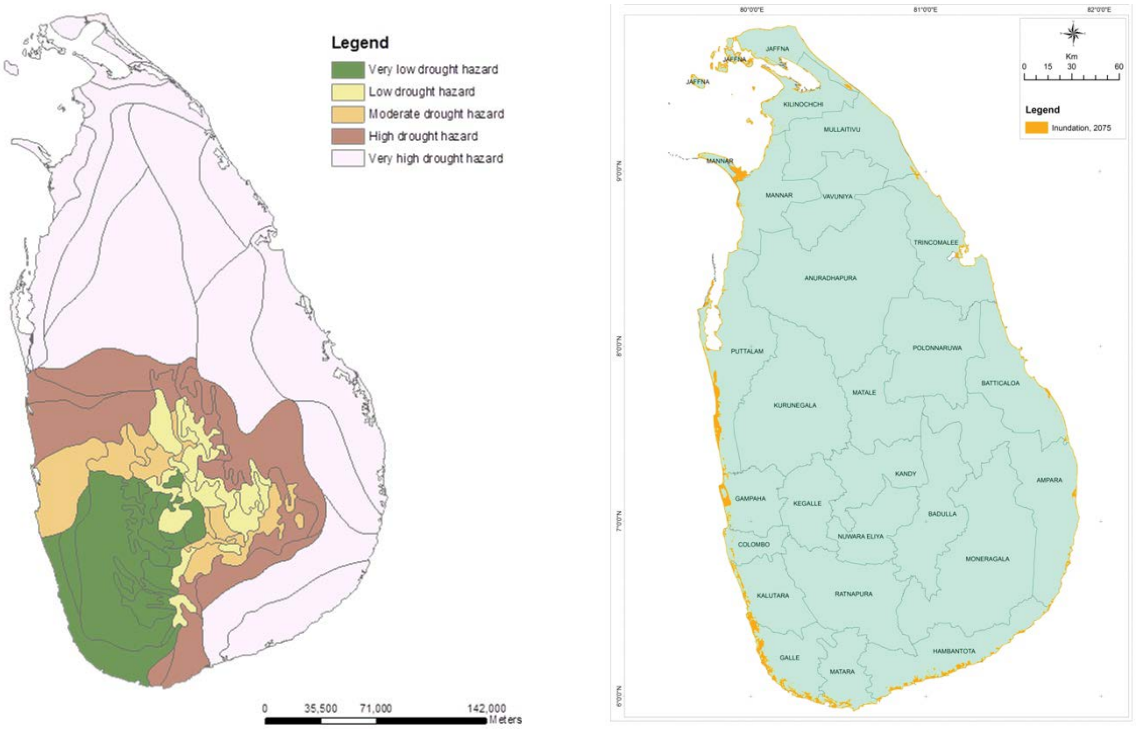


Figure 8: Drought hazard Maps (Left) & Predicted sea level rise in 2075 (Right) (Source: http://www.dmc.gov.lk/hazard/hazard/Maps.html)

8.2 Interview and Focus group findings

All of the interviewees strongly pointed out that it is very important to have MHEWS for increased disaster resilience among the coastal communities. According to SIA01 considering the present status Sri Lanka is mostly involved in post disaster activities.

Every interviewee mentioned that the Tsunami Early Warning is functioning properly and communities living in the coastal lagoons and estuaries could be incorporated to the system.

According to SIL05 for specific weather forecasting local area modelling is required. High performance computer systems are required to do local area modelling to run high-resolution models. It is good at least models can be run for each province. India does this for their

country. Sri Lanka is included in the Regional Models and forecasting but downscaling is required to give localized forecasting. Weather dynamics in the tropical areas are not understood very well therefore; forecasting is difficult to greater accuracies. The weather dynamics in Sri Lanka needs to be compared with other islands to have a better understanding.

"AccuWeather" is widely used by many countries, but the app developed by Department of Meteorology (DoM) is more accurate compared to "Accuweather" for Sri Lanka. However, DoM needs to make it more attractive and user friendly. DoM also have developed a High Heat Index (HHI) with the Ministry of Health that can be effectively used in months April & May to assess the comfort levels due to temperature variation.

In addition, SIG04 stated following efforts towards MHEWS within the country

- Established EW systems
- Trainings (all communities and relevant stake holders)
- Drills
- Awareness
- Plans
- Evacuation routes
- Identification of Safe evacuation points
- Hazard Maps

According to the findings, some said that Sri Lanka does not have a national capability to assess potential multi hazard threat information will other said that it does have up to a satisfactory level.

SIG04 clearly explained the process of MHEW reaching the last mile which is mentioned below.

- DMC cater the information via various EW channels to the District level
- DDMCu's are coping with all ground level activities.
- From the above locations (district / divisional / local authority / Grama Niladhari levels or other identified specific locations) onwards, the dissemination to the communities through following various methods:
- Personnel and agencies such as Local authority officials, GNs, Local Police, CBOs, NGOs, Military, Police and Volunteers will be involved in the dissemination activities.
- The effectiveness of the methods will be different in different locations depending on the location specific characteristics.

In addition, SIG04 mentioned that awareness and training must be a continuous process for Multiple Hazards and people needs training on how to respond to the early warning messages when there is a disaster. A big gap exists even though DMC have trained grass root level. The Samurdhi Officers are in a better position to train and make the communities aware.

Data sharing is a key factor in order to establish an effective Early Warning System. Uncertainty is another factor, which affects early warnings, and it needs to be brought down to 20% less.

'In 2017 May 25 Met Department forecasted 100-120mm of rain and it was expected it will not exceed 600mm, however, the rainfall exceeded 600mm' (SIG04)

After analyzing the literature review and interview findings, importance to have national efforts towards MHEW for increased disaster resilience among coastal communities was identified as mentioned below.

- To improve the community resilience and capacity towards coastal hazards as a whole country
- To gather data and produce information as a whole without specifically focusing on a selected community

9. Policies to improve MHEW in Coastal Resilience

9.1 Literature Review findings

Several policies and plans were commenced with the aim of proper Disaster Management in Sri Lana. Some of the relevant documents with respect to coastal resilience are mentioned below (Refer Annex 1 for further information)

Table 7: Policies, guidelines, reports available for MHEW

Name of the document	Purpose/ Objective
Disaster Management Act No. 13 (DMA)	Provide for the establishment of the NCDM & DMC to appoint TACs and to prepare disaster management plans
National Policy on Disaster Management (NPDM)	Make Sri Lanka to be as resilient and safe as possible from disaster risks
Comprehensive Disaster Management Programme (CDMP)	Ensure the safety of Sri Lanka by reducing the direct and associated potential risk of the country and minimising impacts on people, properties and the economy
National Disaster Management Plan	Reduce disaster impact on communities, infrastructure, lifeline facilities, shelter, agricultural property, economic and development activities in Sri Lanka
Risk assessment and management For tsunami hazard - Case Study for city of Galle	Assess and manage the risk of the coastal city Galle due to Tsunami.
Climate resilient action plans for Coastal urban areas in Sri Lanka	Provide recommendations to the Sri Lankan cities to develop action plans to build disaster resilient cities based on the lessons learnt in the implementation of different project activities
Hazard Resilient Housing Construction Manual	Promote the use of hazard resilient engineering design and construction practices
National Climate Change Adaptation Strategy for Sri Lanka	produce a comprehensive National Climate Change Adaptation Strategy (NCCAS) which lays out a prioritized framework for action and investment for the 2011- 2016 period aimed at systematically moving Sri Lanka and its people towards a climate change resilient future.

When considering the DMA and NPDM currently they are not properly aligned to the global standards (Sendai Framework etc.) and an evaluation process of the existing frameworks is

under way. Hence, it can be concluded that the relevant policies are not yet up to date. All the documents are available online for the public to access freely whenever they need to gather information.

Positive outcomes

- Establishment of last mile communication methods and early warning networks

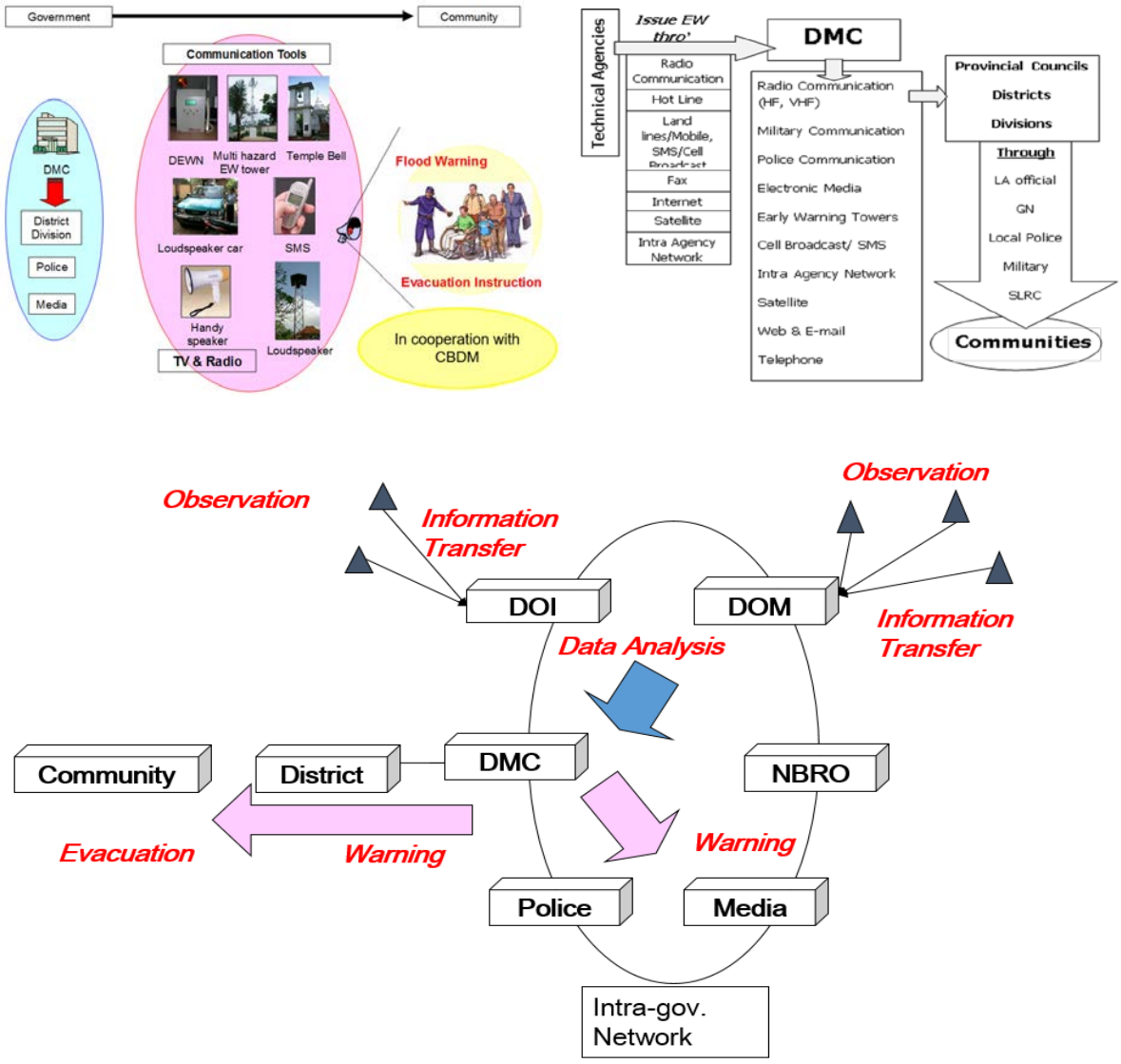


Figure 9: Last mile communication methods & Early warning Network (Hettiarachchi, 2008)

- Implementation of rescue, relief and rehabilitation methods during a disaster
- Capacity building and awareness campaigns
  These campaigns include mock drills, community debriefing, participatory hazard mapping, boat handling, swimming and lifesaving, first aid, search and rescue missions and camp management (Hettiarachchi, 2008)

9.2 Interview/Focus Group findings

After the discussion, the interviewees highlighted following policies and guidelines.

Table 8: Policies, guidelines, reports available for MHEW

Name of the document	Purpose/ Objective
Coast Conservation Act	• Provide for the formulation and execution of schemes of work for coast conservation within the coastal zone • Make consequential amendments to certain written laws
Coastal Zone Management Plan	• Capacity building for management • Control coastal erosion • Facilitate integrated management of coastal resources • Operate permit system and setback standards • Monitor coastal water quality
Disaster Resilient Resettlement Programme for Landslide and Flood Victims	• Implementation Framework for the Resettlement Programme in Kalutara, Galle, Ratnapura and Matara

In addition to the above district disaster response plans and divisional disaster response plans are also available.

Most of the interviewees were not much aware of the existing MHEW related policies related to coastal hazards. In addition, SIG04 mentioned that there are guidelines available for both national and district levels from 2006 onwards. When looking at the success of these policies in improving MHEW among coastal communities it can be concluded that up to a certain extent the objectives were reached.

'In 2012, most of the coastal communities were evacuated once the warning received for the Sumatra EQ' (SIG04)

'Successful in 50% in maintaining physical setbacks to the buildings when it comes to dwellings. Not successful amount 50% for the hotels in maintaining setbacks' (SIL06)

'Governments have a tendency to re-invent policies. As a result policies change frequently, but the implementation remains weak. Continuity is the key' (SIP10)

10. Resilience Mechanisms

10.1 Literature Review findings

Disaster resilient city development strategies for Sri Lankan cities have been introduced by UN habitat program to establish sustainable disaster resilient and healthy cities and townships in disaster prone regions of Sri Lanka. Mannar (UN - Habitat, 2014) and Batticaloa (UN - Habitat, 2013) are two coastal towns, which will be made resilient under those strategies. Some of the strategic directions are mentioned below.

- Improve the physical environment of the city by developing sustainable urban drainage systems and adapting the built environment
- Integrate social and economic development by improving community networks, improve tourism and promoting community savings
- Strengthening the environmental resource management via enhancing the natural vegetation, lagoon, coastal and ground water management
- Establish community mobilization and capacity development by forming disaster response groups, introducing a disaster relief fund, carryout awareness programs and enhancing the trust between organizations and the civil society
- Improve city governance and disaster management by integrating DRR and local development plans and developing guidelines and regulations to mitigate disaster impacts

In addition, National Building Research Organization (NBRO) has issued specific guidelines on how to build resilient houses. Locating the house above the inundation level, slowing down water current using barriers and completely blocking water forces are some of the specifications relevant to coastal hazards.

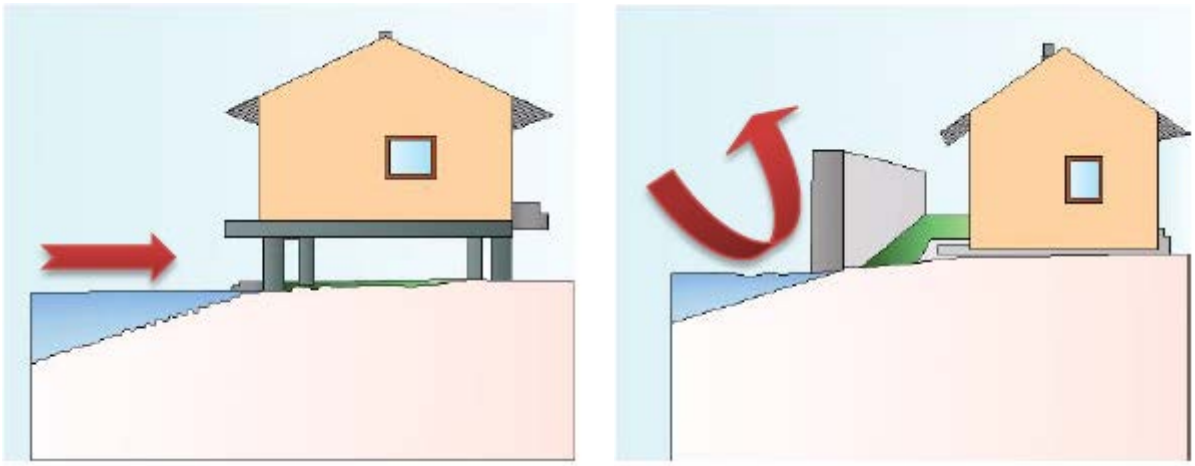


Figure 10: Location of structures to make them resilient for Tsunami (National Building and Research Organization, 2015)

Community resilience framework is another framework developed by DMC for the whole country to achieve resilience through understanding underlying risk factors. It intends to provide an insight into community based resilience for any interested party working on DRR (Disaster Management Centre, 2015b). Currently National Insurance Trust Fund (NITF) covers lives and properties up to LKR 2.5 million each in respect of damages(per event) caused to their property and contents due to Cyclones, Storm, Tempest, Flood, Land slide, Hurricane, Earthquake, Tsunami and any other similar natural perils, excluding Drought (National Insurance Trust Fund, 2016).

10.2 Interview and Focus group findings

During the interviews the investment in coastal resilience mechanisms being less was highlighted. Even though NITF is present, a focused insurance method for coastal hazards does not exist. In addition, SIL06 mentioned that coast protection for eroding shorelines fall under Coastal Zone Management Plan (CZMP) but under the National Planning Department (NPD) coastal zone has not been given the priority, at present CCD is in the process of making it a priority. Following statement was highlighted with respect to sustainable development goals during the interviews.

'Particularly with relations to recent SDGs being at the canter of national development, both hard and soft resilient mechanisms would have strong links to national development plan' (SIA03)

In addition, SIL09 mentioned that NBRO has issues guidelines to prepare for droughts early to conserve food and water.

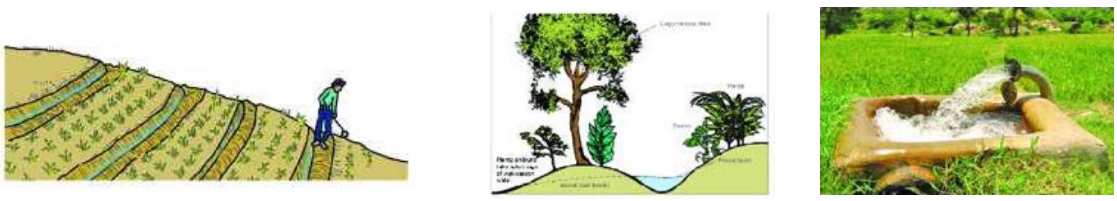


Figure 9: Pictorial diagrams on how to conserve water via proper cultivation (Source: Drought Booklet, NBRO)

After the literature review and interview findings, importance and the existing gaps in coastal resilience mechanisms was identified as below.

- To increase the involvement in community or family activities
- Need a proper insurance policy focused on coastal hazards
- When constructing new buildings resilient guidelines must be properly followed to reduce the vulnerability for a disaster risk
- Planning of resilience mechanisms must start from national level which will have to go down up to the grass root level during implementation

- Updating the existing mechanisms to align them with the global standards and the advanced technology is necessary

11. Regional Cooperation

11.1 Literature Review findings

There are several regional stakeholder partnerships to support effective MHEW and increase the disaster resilience of coastal communities in Sri Lanka. Some of the programs and partnerships are mentioned below.

- Sri Lanka is one of the member states Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) where Department of Meteorology acts as the National Tsunami Warning Centre for the country (Indian Ocean Tsunami Information Center, 2013)
- Sri Lanka is one of the twelve member states of The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES). It's aim is to establish a regional early warning system within a multi-hazard framework for the generation and communication of early warning information, and capacity building for preparedness and response to trans-boundary hazards(Regional Integrated Multi-Hazard Early Warning System for Africa and Asia, 2009)
- Sri Lanka is also a partner of Regional Specialized Meteorological Centre (RSMC) for tropical Cyclones over North Indian Ocean, which will issue tropical weather outlooks and tropical cyclone adversaries in the WMO/ESCAP panel region (Regional Specialized Meteorological Centre, 2013)
- The Coastal Community Resilience (CCR) is a focused initiative funded by Asian Disaster Preparedness Center (ADPC) that promotes tsunami and other hazard readiness through the active collaboration of national and local emergency management agencies, coastal managers, training institutions, and local communities. This will increase public awareness, create minimum standards and promote sustainable livelihood in Sri Lanka(ADPC, 2008)
- Sri Lanka is a member of the Asia Pacific Alliance for Disaster Management (APADM) , an agreement among the stakeholders in order to implement effective and efficient relief and recovery activities (Asia Pacific Alliance for Disaster Management, 2015)n
- Sri Lanka Preparedness Partnership is another initiative which is working towards effective emergency and disaster management through emergency responses. Asian Disaster Preparedness Center (ADPC) has proposed this mechanism to strengthen the Privet-Public Partnership (Jayasooriya, 2018)

11.2 Interview and Focus group findings

According to the interview findings, most of them were aware of the Sri Lanka's position at IOTWMS. DMC is the focal point for it, which has the objective to strengthen the warning system. In addition, some of the programs and partnerships, which came into matter during the discussions, are mentioned below.

- CCD took part in the workshop on Coastal and Marine Risk Mitigation Plan which was held from 27 – 28 March 2008 in India. The workshop was planned to discuss Coastal and Marine Risk Mitigation Plan for each coastal country and for the whole region. SAARC has two specialized regional organizations namely SAARC Coastal Zone Management Centre (SCZMC), Male and SAARC Disaster Management Centre (SDMC). This workshop also highlights that the fact that Sri Lanka being with extensive low-lying areas just above the sea level, are likely to be hard hit by a sea level rise (SAARC, 2008)
- CCD is also working with the Indian Ocean Ring Association (IORA) which has Disaster Management as one of the priority areas. IORA is considering strengthening Disaster management capabilities through collective disaster risk management and enhanced regional mechanisms. Member States are considering what can be done jointly in the areas of early warning, disaster risk reduction and the establishment of regional response capabilities.

Some of the main objectives of the regional cooperation was erosion maintenance, river outlet management, Implementation of CZMP and obtaining assistance in preparation of CZMP and guidelines.

Furthermore, SIP10 highlighted that Sri Lanka should engage in regional dialogue and have mechanisms to incorporate regional knowledge into the national efforts. Regional stakeholder partnerships can be used effectively in capacity building and disaster response. Oil spills is one specific example that require regional partnerships and corporation.

After analyzing the discussions and the literature, following capacity gaps, which hinder effective regional cooperation for MHEW were identified.

- Most of the decision makers are non-technical officers
- Lack of trainings for the officers
- Lack of funds for the incorporations
- Different officers involved in the same process and duplication of the processes
- Public awareness of disaster management is very low
- Capacity needs with respect to training and advancement in Technology (enhanced modelling techniques) should be identified
- Automated information transfer techniques and impact based Early Warning systems should be introduced
- Training materials and awareness campaigns are necessary
- Must cultivate good relationships with Community Based organizations (CBO) and Non- Governmental Organizations (NGO) in order to get the messages to the grass root level
- Efficient information sharing and related capacities (Specially the data on slow-onset disasters like water or air pollution.)
- Use of satellite data and capacity to analyze remotely sensed information can be strengthened with regional co-operation

12. Enablers associated with MHEW in Coastal Resilience

12.1 Literature Review findings

The Developed hazard profile for the entire country is an enabler to develop a Multi Hazard Early Warning System for coastal areas in Sri Lanka. Since it is developed for the whole country accuracy has to be improved when the coastal areas are only being considered. Also towards adapting the climate change in coastal areas Sri Lanka following enablers were identified which are also relevant to MHEWS as well (Athulathmudali et al., 2011).

Table 7: Enablers, which have improved MHEW

Enabler	Description
Eco system resilience	• International concerns • Location threat specific interventions • Prevailing conditions leading to innovations
Knowledge chains	• Better understanding of MHEWS and its need in policy making levels • Carrying out sector/product based research • Bottom up information flow • Use of media to disseminate • Ability to use existing knowledge and skills
Governance structure	• Presidential backing for implementation • Flexibility within the policies • Institutional structures and developed administrative systems • Existing implementation arms • Influencing local and provincial decision makers • Support from extension services
Socio Economic	• Create win – win situations that balance development • Post war context has created new opportunities for income • Financial resources • Support form external organizations

12.2 Interview and Focus group findings

SIP10 mentioned that the release of dams and resulting sudden additions of water to coastal area due to climate induced floods; ocean acidification due to climate change and temperature relationship with MHEW needs to be included in new MHEWS.

Following enablers were identified for an effective MHEW towards coastal resilience after the discussions with the interviewees.

Enablers / Barriers	Interviewee Code/s	Frequency of mentions
community management	SIL06	3
community awareness	SIL11	10
Integrating local knowledge	SIL11	2
Multi – stakeholder and multi –agency cooperation	SIL11	6
Data Exchange	SIL05	7
Risk Assessment	SIG07	1
Financial Support	SIL09	4
Focal Evacuation & Compensation	SIL06	3
Capacity Development	SIL06	9
Community based EW systems	SIL11	2

13. Role of Higher Education Institutes for an effective MHEW and Coastal Resilience

13.1 Literature Review findings

There are several government and private universities in Sri Lanka, which provide their knowledge and expertise for effective MHEW and coastal resilience. Some of the key involvements are tabulated below

Table 8: Involvements of HEI in Sri Lanka with MHEWS

University	Involvements/ actions / programmes
University of Moratuwa	• Involvement in the UNESCO/ IOC/ Indian Ocean Tsunami Warning System (IOTWS) since its inception in 2005 • Introduction of an ICT based Disaster Early Warning Network (DEWN) for DMC (Wickramasinghe, 2013) • Offer Under graduate & Post graduate course involving coastal engineering and management (University of Moratuwa, 2017) • Conference and Journal publications about early warning systems in Sri Lanka (Hettiarachchi and Weeresinghe, 2014) • Sharing knowledge and expertise in regional workshops for coastal hazards(IOC Capacity Development, 2013)
University of Peradeniya	• Development of Tsunami hazard mapping for five cities devastated by 2004 Tsunami (Wijethunge, 2008) • Offers and MSc in Disaster Management (Postgraduate Institute of Science University of Peradeniya, 2017) • Several publications related to community preparedness of social communities in Sri Lanka(Karunaratne, 2015) • Sharing knowledge and expertise in regional workshops for coastal hazards(IOC Capacity Development, 2013)
Other state Universities	• Organizing workshops related to impact of climate change to the coastal zone (Department of Geography, 2016)
Private Sector Universities	• Several publications related to Disaster Management (Ahangama and Prasanna, 2015)

13.2 Education and awareness programmes: Interview and Focus group findings

Some of the interviewees mentioned that they are not much aware about the education and awareness programmers for coastal hazards. But according to SIG04 DMC is currently conducting several EW awareness and training campaigns for the coastal communities. The capacities need to be enhanced to achieve the target outcome from them.

In addition, SIA01 mentioned that Open University of Sri Lanka conduct courses on Disaster Management, climate change and ground water resources management and pollution control. These courses focus on the coastal communities up to a certain extent.

SIL06 mentioned that 5th Asia-Pacific Climate Change Adaptation Forum was held in Sri Lanka which included a separate session on climate resilient development. Ministry of Mahaweli Development and Environment was one of the key organizers of this event. (UNDP Regional Office for Asia and the Pacific, 2016)

Most of the interviewees mentioned that DMC is responsible for the MHEW education while SIL06 mentioned that CCD must also be involved in the MHEW education when it comes to coastal areas.

13.3 Role of the HEI: Interview and Focus group findings

During the discussions with the interviewees several key information were gathered regarding the role of Higher Education Institutes in improving MHEW for Coastal Resilience.

a. **Education**
   Education curriculums could integrate social learning processes that deals with coastal resilience to hazards. Integrating the topic to student projects in fields such as Civil Engineering, coastal and environmental engineering, sustainable development would enrich engineering education with other useful topics such as social designs, long-term perspective, resilience, vulnerability etc. In addition, SIA01 mentioned that the courses are open for government employees as well but participation is a problem due to lack of motivation. Most of the certificate programs cost around LKR 10,000 and 100 hrs. of education for one year. Sponsorships are required to enhance the participation. Private sector and NGOs participate willingly. Furthermore, SIP10, mentioned that HEI's need to update the curricula to adopt to new technologies, changing climate and resulting new/enhance hazards etc. At the same time HEIs needs to make Disaster Management attractive to be taken as a profession or major component of other professions.

b. **Expertise/ advocacy**
   As already happening in Sri Lanka, the experts could engage in policy advocacy. Organizing such expert consultancy by interdisciplinary groups of experts may support well in addressing complexities of coastal resilience. In addition, they should take part

in the National Disaster Management Committee and the plans must be more people oriented. In addition, SIP10 mentioned that professional advocacy needs to be based on global and local knowledge based on facts.

c. **Research**
Cross-disciplinary and transdisciplinary research on MHEWS should be encouraged. In addition, the innovations must be low cost and community focused with the ease of implementation. Research dissemination should be web based even though it is not the current trend in Sri Lanka. Furthermore, during the data collection stages more focus should be given to the communities and village level involvement rather than the officers in national levels as well as more partnerships with practitioners is the key for applied research.

d. **Other ways**
Representatives from HEIS can participate in drills and advise, incorporate with all the activities of DM sector. Integrating academic and professional development to the social impact process is another way where HEIs can contribute.

13.4 Barriers faced by HEIs: Interview and Focus group findings

a. Challenges faced

According to SIA03, the mismatch of expectations by diverse stakeholders such as the academic experts, funding organizations, policy networks, affected communities, general public etc, hinders successful coordination of projects, and hinders the social impact. HEIs often face the challenge of their research findings are overlooked in the policy formulation process.

In addition less attendance for the programmes and duplicate innovations are some of the problems, which exist in HEIs highlighted by SIG04. Furthermore, exposure for the local graduates is less in the field of Disaster Management.

Furthermore, SIP10 mentioned that In adequate resources; lack of capacity to think beyond the main subject area or expertise and developing integrated solutions by partnering with other entities/agencies; In country issues in obtaining patents for new technology developments and poor recognition are some of the main obstacles faced by HEIS.

b. How to overcome

HEIs must be aware of the responsibilities to create social impact. They should have a clear strategy to address the identified barriers. Adopting long-term approaches and Integrating with national budgets, Continuous dialogue among agencies with better coordination are some of the key points highlighted by SIP10. Encouraging and supporting researchers to work with other stakeholders such as the policy makers, affected communities, encouraging relevant research with long term societal impact, fostering reflexive research attitude in young researchers, encouraging and providing institutional

environment that support transdisciplinary contextual research are some of the ways to overcome the barriers

In addition HEIs must actively engage with DMC and conduct more research and encourage to include courses and modules within the National Education Systems in all levels.

c. How to provide effective support

Formulating and conducting research that integrate aspects such as long-term sustainability and resilience of communities as key focuses, and integrate diverse stakeholders is necessary. In addition, HEIs can strive to design their research in a way that research efforts themselves could become key drivers of capacity building in societies. Particularly in Sri Lankan context, although challenging, all HEIs also can make extra effort to be more integrated to the national and regional policy process. Industry – HEI linkages for mutual benefits and synergy is a natural way of building capacity. Inter-HEI exchanges (local and abroad) is a must. HEI staff should undertake national level assignments as a part of the work and engage students in national problem solving.

14. Conclusions and Recommendations

14.1 Conclusions

After assessing the data gathered following conclusions were made with respect to the status of MHEWS in coastal resilience.

a. Identifying the impacts of coastal hazards at all levels is important before developing a Multi Hazard Early Warning System for coastal resilience
b. Sri Lanka has a detailed Early Warning Dissemination System where the productivity and efficiency is questionable considering the recent disasters
c. Sri Lanka has done hazard assessments for the coastal hazards individually, but has not carried out detailed multi – hazard assessment focusing on the coastal zone.
d. Current National policies and frameworks related to coastal hazards are yet to be aligned to the post 2015 global frameworks
e. After the 2004 Indian Ocean Tsunami Sri Lanka has put lot of effort in Tsunami Early Warnings while the focus on other disasters like adverse weather conditions
f. At present the lack of inter-agency cooperation and advanced technology has generated inefficiency in the existing early warning systems
g. Some of the policies which exist do not focus directly on coastal hazards but the ones which do, are not getting updated in a recurring manner
h. Both soft and hard resilience mechanisms for coastal hazards must be upgraded to build the capacity of the coastal communities
i. Sri Lanka has involved in regional efforts for coastal resilience in a satisfactory way
j. Training and public awareness campaigns, efficient funds, properly maintained hierarchy and concern to the coastal eco systems are some of the enablers associated with MHEW in coastal resilience
k. Role of Higher Education Institutes in MHEWs and coastal resilience is very important in education and awareness programs as well as on research work for new inventions.
l. Mismatch of expectations of the stakeholders and lack of participation in the awareness programs are some of the barriers HEIs face in their role of MHEW

14.2 Recommendations

Following recommendations are suggested in order to produce an effective and efficient MHEWS for coastal resilience.

a. Develop a multi hazard map targeting the coastal areas
b. Integrate early warnings into development processes and public policies
c. Align and update the existing frameworks and policies to match the global standards so that the country can gain international recognition and aid in developing MHEWS for Sri Lanka

d. Improve the interagency cooperation and use advance technological methods to improve the efficiency of the existing Early Warning System
e. Integrate soft and hard resilience mechanisms for coastal hazards
f. Involve in regional efforts on MHEWS and take a leading role to improve the performance of MHEWS
g. Carryout training and public awareness campaigns in an effective manner to increase the participation of the villagers, target communities and the relevant officers
h. Increase the input from HEIs in decision making and provide sufficient funds to carry out research work to strengthen the MHEWS
i. Improve the data availability for investigating, forecasting/predicting and managing risks on different time scales
j. Introduce mechanisms for sustaining the early warning dialogue and supporting the development
k. Focus more on the development of a people-centered MHEWS (A sample flow chart is attached below)

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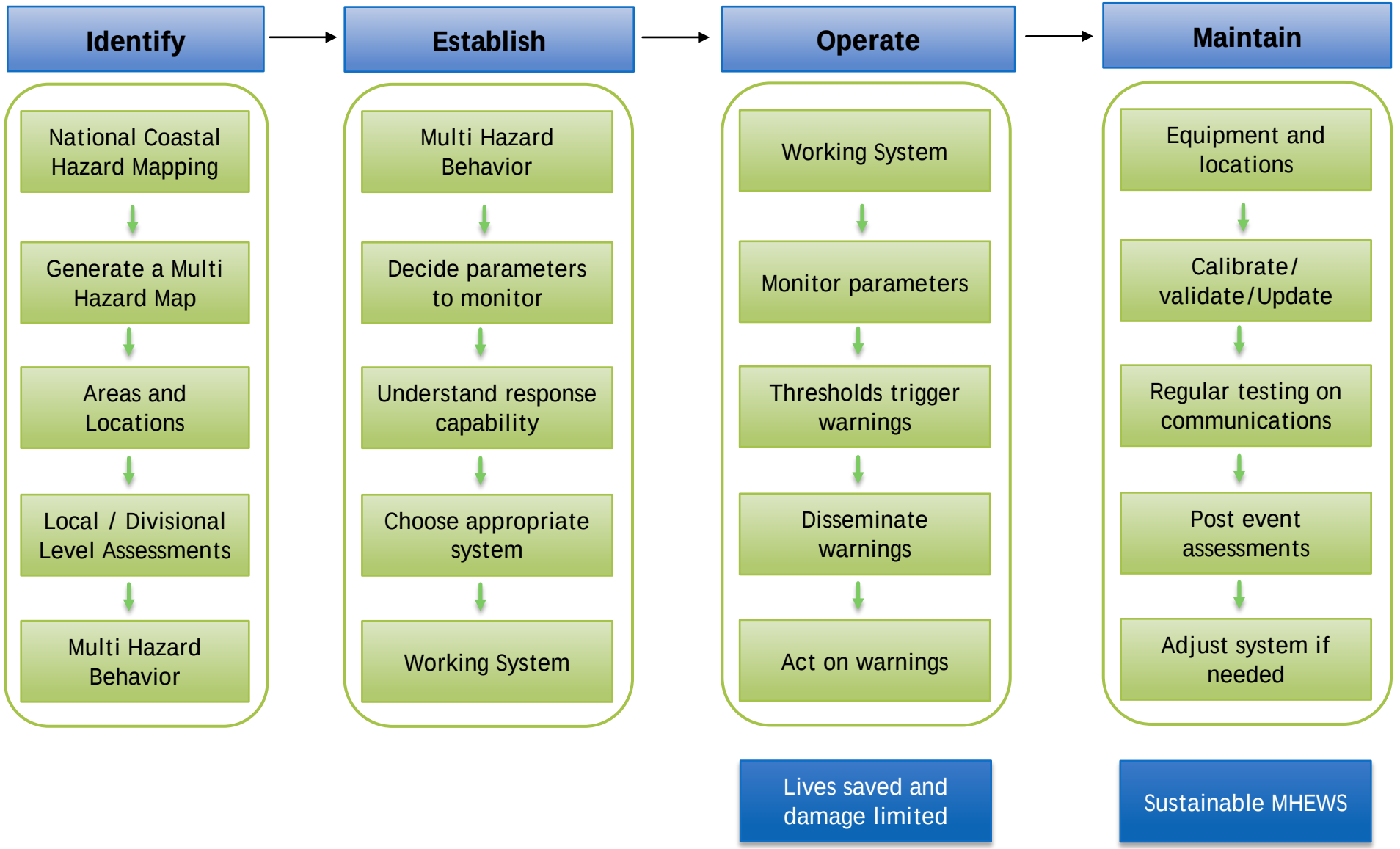

List of References

ADPC. (2008), *Training Workshop on Coastal Community Resilience (CCR) in Sri Lanka*.

Ahangama, N. and Prasanna, R. (2015), "Disaster Risk Management and Resilience : What Remains Untouched ?", *Journal of Management*, Vol. 1 No. 1, pp. 52–72.

Asia Pacific Alliance for Disaster Management. (2015), "About A-PAD", available at: http://apadm.org/lp/ (accessed 3 August 2017).

Athulathmudali, S., Balasuriya, A. and Fernando, K. (2011), *An Exploratory Study on Adapting to Climate Change in Coastal Areas of Sri Lanka*, available at: http://www.cepa.lk/uploads/3440468ac559206240319c83158793e2-Climate-Change.pdf.

Briney, A. (2017), "Geography of Sri Lanka", available at: https://www.thoughtco.com/geography-of-sri-lanka-1435578 (accessed 30 July 2017).

Department of Geography, U. of C. (2016), "Workshop on Climate Change and Anthropogenic Activities : Impact on Coastal Development and Management", available at: http://www.cmb.ac.lk/academic/arts/Geo/news&events.html (accessed 29 July 2017).

Disaster Information Management System. (2012), "Disaster Event & Impact Profile", *Sri Lanka National Report on Disaster Risk, Poverty and Human Development Relationship*, pp. 37–57.

Disaster Management Centre. (2012), *Hazard Profiles of Sri Lanka*.

Disaster Management Centre. (2015a), "National Emergancy Operations Plan Vol I".

Disaster Management Centre. (2015b), *Community Resilience Framework Sri Lanka*.

Garcin, M., Desprats, J.F., Fontaine, M., Pedreros, R., Attanayake, N., Fernando, S., Siriwardana, C.H.E.R., et al. (2008), "Integrated approach for coastal hazards and risks in Sri Lanka", *Natural Hazards and Earth System Science*, Vol. 8 No. 3, pp. 577–586.

Garcin, M., Ignatius, W., Fernando, S., Desprats, J., Garcin, M., Attanayake, N. and Pedreros, R. (2010), "A â€™ coastal-hazard GIS â€™ for Sri Lanka", No. July 2017, available at:https://doi.org/10.2307/40665348.

Gunasekara, I.P.A. (2008), "Flood Hazard Mapping in Lower Reach of Kelani River", *Engineer*, Vol. XXXXI No. 5, pp. 149–154.

Helgeson, T.J. (2005), "Tsunami Disaster in Sri Lanka", available at: http://academic.evergreen.edu/g/grossmaz/HELGESTJ/ (accessed 29 July 2017).

Hettiarachchi, G. (2008), *Disaster Management Activities in Sri Lanka*, available at: http://www.protezionecivile.gov.it/resources/cms/documents/srilanka.ppt.

Hettiarachchi, S.S.L. and Weeresinghe, S. (2014), “Achieving Disaster Resilience through the Sri Lankan Early Warning System: Good practises of Disaster Risk Reduction and Management”, *Procedia Economics and Finance*, Elsevier B.V., Vol. 18 No. September, pp. 789–794.

Illangasekare, T., Tyler, S.W., Clement, T.P., Villholth, K.G., Perera, A.P.G.R.L., Obeysekera, J., Gunatilaka, A., et al. (2006), “Impacts of the 2004 tsunami on groundwater resources in Sri Lanka”, *Water Resources Research*, Vol. 42 No. 5, available at:https://doi.org/10.1029/2006WR004876.

Indian Ocean Tsunami Information Center. (2013), “SRI LANKA”, available at: http://iotic.ioc-unesco.org/state/23/sri-lanka (accessed 28 July 2017).

IOC Capacity Development. (2013), “Regional Workshop on Coastal Hazard Assessment: Applications in Risk Assessment, Management and Mitigation”.

Japan International Cooperation Agency. (2017), *DATA COLLECTION SURVEY ON DISASTER RISK REDUCTION*.

Jayasooriya, S. (2018), “SRI LANKA PREPAREDNESS PARTNERSHIP: 18% OF WORK COMPLETED”, *Sunday Observer*, available at: http://www.sundayobserver.lk/2017/11/19/business/sri-lanka-preparedness-partnership-18-work-completed.

Jayaweera, D.M.. (2012), *Early Warning Systems for Disasters in Sri Lanka*.

Karunaratne, B.S.B. (2015), *Community Preparedness and Resilience in a Coastal Community on Mannar Island , Sri Lanka*.

Ministry of Disaster Management. (2014), *Sri Lanka Comprehensive Disaster Management Programme*.

Ministry of Home Affairs. (2017), *Bulletin of Vital Statistics*.

National Building and Research Organization. (2015), *Hazard Resilient Housing Construction Manual*.

National Council for Disaster Management. (2010), *National Policy on Disaster Management*.

National Insurance Trust Fund. (2016), “National Natural Disaster”, available at: http://www.nitf.lk/National Natural Disaster.html (accessed 29 July 2017).

Postgraduate Institute of Science University of Peradeniya, S.L. (2017), “MSc . in Disaster Management”.

Prevention Web. (2015), *National Progress Report on the Implementation of the Hyogo Framework for Action (2013-2015)*, available at:https://doi.org/10.4324/9780203938225.ch5.

Prevention Web. (2017), *Sendai Framework Data Readiness Review - Sri Lanka*.

Regional Integrated Multi-Hazard Early Warning System for Africa and Asia. (2009), "Overview", available at: http://www.rimes.int/about_overview.php (accessed 3 August 2017).

Regional Specialized Meteorological Centre. (2013), "Panel Members", available at: http://www.rsmcnewdelhi.imd.gov.in/index.php?option=com_content&view=article&id=127&Itemid=420&lang=en (accessed 23 July 2017).

Relief Web. (2017), "Sri Lanka: Floods and Landslides - May 2017", available at: http://reliefweb.int/disaster/fl-2017-000057-lka (accessed 29 July 2017).

SAARC. (2008), *Regional Cooperation on Coastal and Marine Risk Mitigation Plan for South Asia*.

Samarasinghe, S., Nandalal, H., Weliwitiya, D., Fowze, J., Harazika, M. and Samarakoon, L. (2010), "Aplication of Remote Sensing and GIS for Flood Risk Analysis:A Case Study at Kalu - Ganga River, Sri Lanka", *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Science*, Vol. XXXVIII No. 8, pp. 110–115.

De Silva, D.A.M. and Yamao, M. (2007), "Effects of the tsunami on fisheries and coastal livelihood: A case study of tsunami-ravaged southern Sri Lanka", *Disasters*, Vol. 31 No. 4, pp. 386–404.

Silva, W. (2016), "Flooding The Economy", available at: http://www.thesundayleader.lk/2016/05/29/flooding-the-economy/ (accessed 29 July 2017).

The World Bank. (2014), "Sri Lanka's Early Warning System", available at: http://www.worldbank.org/en/country/srilanka/brief/fact-sheet-srilankas-early-warning-system (accessed 25 July 2017).

UN - Habitat. (2013), *Batticaloa - Disaster Risk Reduction and Preparedness Plan*.

UN - Habitat. (2014), *Mannar - Disaster Risk Reduction and Preparedness Plan*.

UNDP Regional Office for Asia and the Pacific. (2016), "5th Asia-Pacific Climate Change Adaptation Forum", available at: http://www.asiapacificadapt.net/adaptationforum/2016/streams-and-sessions (accessed 28 July 2017).

unicef. (2017), *Sri Lanka Humanitarian Situation Report No.5*.

UNISDR. (2016), *Asia Regional Plan for Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030*, Vol. 15.

University of Moratuwa. (2017), "MSc / PG Diploma in Environmental Engineering and Management", available at: http://www.mrt.ac.lk/web/content/msc-pg-diploma-

environmental-engineering-and-management (accessed 29 July 2017).

Wickramasinghe, K. (2013), “Role of ICTs in Early Warning of Climate-Related Disasters: A Sri Lankan Case Study”, available at: http://climatenet.blogspot.com/2013/12/role-of-icts-in-early-warning-of.html.

Wijethunge, J. (2008), *Mapping the Threat*.

Zubair, L., Ralapanawe, V., Tennakoon, U., Yahiya, Z. and Perera, R. (2006), “Natural disaster risks in Sri Lanka : Mapping hazards and risk hotspots”, *Natural Disaster Hotspots: Case Studies*, pp. 109–136.

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APPENDIX 1:

The following table lists all the policies, guidelines, national/local report available for MHEW in Coastal Resilience. Please fill in as much information as possible.

Name of the Document	Document Reference	Brief Description of the Document	Main initiatives/Actions highlighted in the Document	Key Informants (if given)
i.e. Policy, Guideline, National Report, etc.	**i.e. Author(s)/Institution Name, Year of Publication, Web Source (if online)**	**i.e. What is it about, it's main purpose, Why was it introduced, is the document aimed at at National Level/ Regional Level/ City Level/ Village Level/ any other, etc.**	**This can be in the form of bullet points and you have to highlight ONLY the main initiatives/actions stipulated in the document.**	**If there is a list of key people involved in the development of the document, you can list them here in (their name, position and contact number/e-mail. This will be helpful when you start your Interviews and/or focus groups.**
LITERATURE REVIEW FINDINGS				
1. Disaster Management Act No. 13	Parliament of Sri Lanka, 13 May 2005, (http://www.dmc.gov.lk/attchments/DM%20Act%20English.pdf)	The purpose is to provide for the establishment of the NCDM & DMC to appoint TACs and to prepare disaster management plans. It was produced because of the widespread destruction caused by Tsunami. It is aimed at national level	a. Provide for the institutional structure to be adopted to facilitate disaster management activities b. Provide legal framework for NCDM c. Authorises president to declare when an impending disaster cannot be counteracted with resources normally available to the administration	-
2. National Policy on Disaster Management (NPDM)	National Council for Disaster Management,2010 (revised on 2014), (http://www.disastermin.gov.lk/web/images/pdf/sri%20lanka%20disaster%20	The purpose is to make Sri Lanka to be as resilient and safe as possible from disaster risks. It was introduced to provide policy directives to address the issues which were	a. Achieve low vulnerability and high resilience to a disaster by following a systematic approach b. Improve preparedness and response c. Establish integrated systems to reduce the risk	a. 2005 Parliament Select Committee on Natural Disasters

	management%20policy%20english.pdf)	identified in the aftermath of the 2004 Tsunami and the other recent disaster situations. It is aimed at national level	d. Provide fiscal disaster resilience to disasters e. Educate and train professionals in DM	
3. Comprehensive Disaster Management Programme	Ministry of Disaster Management, 2014, (http://www.disastermin.gov.lk/web/images/pdf/slcdmp%20english.pdf)	The purpose is to ensure the safety of Sri Lanka by reducing the direct and associated potential risk of the country and minimising impacts on people, properties and the economy. It was introduced due to the recommendations of UNDAC Assessment in 2011. It is aimed at all levels	a. Setup legal and institutional systems b. Prepare vulnerable communities for disasters c. Enhance efforts to minimize disaster risks	-
4. National Disaster Management Plan	Disaster Management Centre, 2013, (http://www.dmc.gov.lk/NDMCC/presentations/Imlementation%20Meeting%2019th%20Sep%202014.pdf)	The purpose is to reduce disaster impact on communities, infrastructure, lifeline facilities, shelter, agricultural property, economic and development activities in Sri Lanka. This was introduced to translate NPDM in to action. It is aimed at all levels.	a. Establish mechanisms/systems for Disaster Risk Management in Sri Lanka as a multi- sectoral, inter-ministerial, and inter-agency activity b. Incorporates all aspect such as, institutional mandated & institutional development; hazard, vulnerability & risk assessment; multi-hazard early warning systems; disaster preparedness and response planning; disaster mitigation and integration into development planning	
5. Risk assessment and management For tsunami hazard - Case Study for city of Galle	UNDP, 2011, (http://www.asia-pacific.undp.org/content/dam/rbap/docs/Research%20&%20Publications/CPR/APRC-CPR-2011-RA-TsunamiHazardGalle.pdf)	The purpose is to assess and manage the risk of the coastal city Galle. This was produced because in order to develop uniform guidelines on tsunami risk assessment. It is aimed at city level	a. Prepare hazard, vulnerability and risk maps for the port of Galle b. Establish resilience of coastal communities	a. Prof. S.S.L. Hettiarachchi, University of Moratuwa, Sri Lanka b. Dr. S.P. Samarawickrama, University of Moratuwa, Sri Lanka c. Dr. N. Wijeratne, University of Ruhuna, Sri Lanka

6. Climate resilient action plans for Coastal urban areas in Sri Lanka	University of Moratuwa (UOM) Norwegian Institute for Water Research (NIVA) United Nations Human Settlement Programme (UN- HABITAT) Batticaloa Municipal Council (BMC) Negombo Municipal Council (NMC), 2013, (http://www.fukuoka.unhabitat.org/programmes/ccci/pdf/SRL4_Climate_Resilient_Action_Plans.pdf)	The purpose is to provide recommendations to the Sri Lankan cities to develop action plans to build disaster resilient cities based on the lessons learnt in the implementation of different project activities. It is aimed at national level	a. Water resource management b. Identify drainage and sanitation impacts from more intense rainfall events c. Establish multi-purpose green belt (12 km in length) to protect the lagoon and coastal areas d. Establish GIS-based Rapid Response Systems (RRS) & two Knowledge Management centres for climate exacerbated disasters e. Disaster resilient; energy efficient; low-cost shelter adaptation training	a. Prof. P.K.S.Mahanama Dean, Faculty of Architecture Team Leader, UoM b. Mr. K. Sivanathan Commissioner, Batticaloa Municipal Council c. Ms. Mallika Fernando Commissioner, Negombo Municipal Council
7. Hazard Resilient Housing Construction Manual	National Building Research organization, 2013, (http://www.nbro.gov.lk/images/content_image/publications/general_publications/resilient_manual.pdf)	The purpose is to promote the use of hazard resilient engineering design and construction practices. It is aimed at the national level	a. Minimize the risk associated with individual houses built in natural hazard prone localities. b. Minimize the damage to structural elements c. Provide technical information as much as possible in a single reference material	a. Prof Priyan Dias, UoM b. Prof S. Hettiarachchi, UoM c. Prof Kapila Dahanayake, UoP
8. National Climate Change Adaptation Strategy for Sri Lanka	Climate Change Secretariat, Ministry of Environment and the Asian Development Bank,16 Nov 2010 (https://www.climatechange.lk/adaptation/Files/Strategy_Booklet-Final_for_Print_Low_res(1).pdf)	The purpose of the document is to produce a comprehensive National Climate Change Adaptation Strategy (NCCAS) which lays out a prioritized framework for action and investment for the 2011-2016 period aimed at systematically moving Sri Lanka and its people towards a climate change resilient future.	a. Mainstream Climate Change Adaptation into National Planning and Development b. Enable Climate Resilient and Healthy Human Settlements c. Minimize Climate Change Impacts on Food Security d. Improve Climate Resilience of Key Economic Drivers	a. Nayana Mawilmada - Team Leader/Strategic Planning Specialist b. Sithara Atapattu -Deputy Team Leader/Coastal Ecologist, c. Jinie Dela - Environmental Specialist

			e. Safeguard Natural Resources and Biodiversity from Climate Change Impacts	
f. **INTERVIEW/FOCUS GROUP FINDINGS**				
9. Coast Conservation Act	Parliament of Sri Lanka, 9 September 1981, (http://extwprlegs1.fao.org/docs/pdf/srl5289.pdf)	The purpose is to allocate provisions for a survey of the coastal zone and the preparation of a coastal zone management plan. It is aimed at national level.	a. Provision for the formulation and execution of schemes of work for coast conservation within the coastal zone b. Make consequential amendments to certain written laws.	
10. Coastal Zone Management Plan	Coast Conservation Department, 2006, (http://www.coastal.gov.lk/downloads/pdf/CZMP%20English.pdf)	The purpose is to manage the coastal zone to ensure sustainable use of the coastal environment and its resources. This was produced because of the need risen for an integrated management for the coastal zone. This is aimed at all levels.	a. Capacity building for management b. Control coastal erosion c. Facilitate integrated management of coastal resources d. Operate permit system and setback standards e. Monitor coastal water quality f. Institutional collaboration	
11. Implementation Framework for the Resettlement Programme in Kalutara, Galle, Ratnapura and Matara	National Building Research Organization (http://www.nbro.gov.lk/index.php?option=com_content&view=article&id=24&Itemid=178&lang=en)	To resettle the families living in hazard prone areas of Ratnapura, Kalutara, Galle and Matara Districts.	a. Preparation of resilient house plans b. Provides a guideline to the resettlement programme for the information of the District Secretaries and other relevant officers, who are involved in the resettlement process to ensure successful implementation.	
12. Guidelines for construction in landslide prone areas	National Building Research Organization (http://www.nbro.gov.lk/index.php?option=com_content&view=article&id=24&Itemid=178&lang=en)	Provides guidelines in local language for the families to construct houses in hazard prone areas	a. Provides construction guidelines and relevant dimensions	

---- End of Report ----