ANALYSIS OF DISASTER MANAGEMENT FRAMEWORKS TO EVALUATE THE HAZARD INDUCED RISKS OF COASTAL COMMUNITIES

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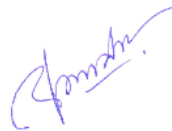Name of the supervisor: Prof. P.B.R. Dissanayake

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Abstract

Natural hazards were recognized globally as the most pressing risk in terms of impact and probability of occurrence. This context presses the need for strong, effective risk management mechanisms in the field of disaster management. Yet the ever increasing casualties, economic losses due to natural hazards raise the question on the effectiveness of respective mechanisms to mitigate such. That leads to the objective of this research work, to find engineered solutions for the disaster risk management mechanism to be more effective.

The research work conducted in three phases. First a literature survey to identify the risk management principles, disaster management principles, and disaster and risk relativity and evaluation methods. The next phase is framework development. Number of frameworks were developed as part of the research work to evaluate the effectiveness of a disaster management mechanism and to capture the details of a given mechanism. Third phase is the three case studies in three countries, Sri Lanka, Myanmar and Maldives. Collected data were then analyzed to capture an ideal disaster management mechanism.

It was identified that there are number of factors can include in to a disaster management mechanism from a risk management perspective. Also it was identified that the developed frameworks do capture the details of a disaster management mechanism in a satisfactory way. There are number of practices countries can share within to enhance the mechanisms. Also the research work concluded with an institutional ideal arrangement in a disaster risk management perspective.

Key Words: Risk Management, Disaster Management

Acknowledgements

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1 INTRODUCTION

1.1 Context

Engineering is the application of science and mathematics to solve predicament. Engineers Find practical solutions and figure out how things work while designing, assessing, reviewing, developing, testing, modifying, installing, and maintaining a wide variety of systems, processes and products. [1] The following research work is about evaluating risk management (for natural hazards) mechanisms and finding an efficient mechanism.

In the 2019 Global Risk Report produced by the World Economic Forum illustrates the world risks under five categories, namely; Economic, Environmental, Geopolitical, Societal and Technological. [2] As illustrated in Figure 1 the risks are rated for the likelihood and impact.

If we historically analyze the risks along categories we can observe that in the start of the last decade how economic risks subjugated the world risks and how by the end of the decade environmental risks started having further impact and probability. This observation is produced from the following calculation presented in Table 1 and Figure 2. A weightage of 5 was given to the top risk and a 1 to the top 5th risk. Total was the multiplication of both values produced from likelihood and impact.

Top 5 Global Risks in Terms of Likelihood

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1st	Asset price collapse	Asset price collapse	Storms and cyclones	Severe income disparity	Severe income disparity	Income disparity	Interstate conflict with regional consequences	Large-scale involuntary migration	Extreme weather events	Extreme weather events	Extreme weather events
2nd	Slowing Chinese economy (<6%)	Slowing Chinese economy (<6%)	Flooding	Chronic fiscal imbalances	Chronic fiscal imbalances	Extreme weather events	Extreme weather events	Extreme weather events	Large-scale involuntary migration	Natural disasters	Failure of climate-change mitigation and adaptation
3rd	Chronic disease	Chronic disease	Corruption	Rising greenhouse gas emissions	Rising greenhouse gas emissions	Unemployment and underemployment	Failure of national governance	Failure of climate-change mitigation and adaptation	Major natural disasters	Cyber-attacks	Natural disasters
4th	Global governance gaps	Fiscal crises	Biodiversity loss	Cyber-attacks	Water supply crises	Climate change	State collapse or crisis	Interstate conflict with regional consequences	Large-scale terrorist attacks	Data fraud or theft	Data fraud or theft
5th	Retrenchment from globalization	Global governance gaps	Climate change	Water supply crises	Mismanagement of population	Cyber-attacks	High structural unemployment or underemployment	Major natural catastrophes	Massive incident of data fraud/theft	Failure of climate-change mitigation and adaptation	Cyber-attacks

Top 5 Global Risks in Terms of Impact

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1st	Asset price collapse	Asset price collapse	Fiscal crises	Major systemic financial failure	Major systemic financial failure	Fiscal crises	Water crises	Failure of climate-change mitigation and adaptation	Weapons of mass destruction	Weapons of mass destruction	Weapons of mass destruction
2nd	Retrenchment from globalization (developed)	Retrenchment from globalization (developed)	Climate change	Water supply crises	Water supply crises	Climate change	Rapid and massive spread of infectious diseases	Weapons of mass destruction	Extreme weather events	Extreme weather events	Failure of climate-change mitigation and adaptation
3rd	Oil and gas price spike	Oil price spikes	Geopolitical conflict	Food shortage crises	Chronic fiscal imbalances	Water crises	Weapons of mass destruction	Water crises	Water crises	Natural disasters	Extreme weather events
4th	Chronic disease	Chronic disease	Asset price collapse	Chronic fiscal imbalances	Diffusion of weapons of mass destruction	Unemployment and underemployment	Interstate conflict with regional consequences	Large-scale involuntary migration	Major natural disasters	Failure of climate-change mitigation and adaptation	Water crises
5th	Fiscal crises	Fiscal crises	Extreme energy price volatility	Extreme volatility in energy and agriculture prices	Failure of climate-change mitigation and adaptation	Critical information infrastructure breakdown	Failure of climate-change mitigation and adaptation	Severe energy price shock	Failure of climate-change mitigation and adaptation	Water crises	Natural disasters

Legend: ■ Economic ■ Environmental ■ Geopolitical ■ Societal ■ Technological

Figure 1: Global Risks from 2009 to 2019 (Source: World Economic Forum Risk Perception Survey 2018-2019, [2])

Table 1: Calculated risk values from 2009 to 2019

Category	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	23	24	8	12	12	10	1	1	0	0	0
Environmental	0	0	16	8	9	13	5	9	15	19	20
Geopolitical	2	1	6	0	2	0	15	6	7	5	5
Societal	5	5	0	8	6	5	9	10	7	1	2
Technological	0	0	0	2	0	2	0	0	1	5	3
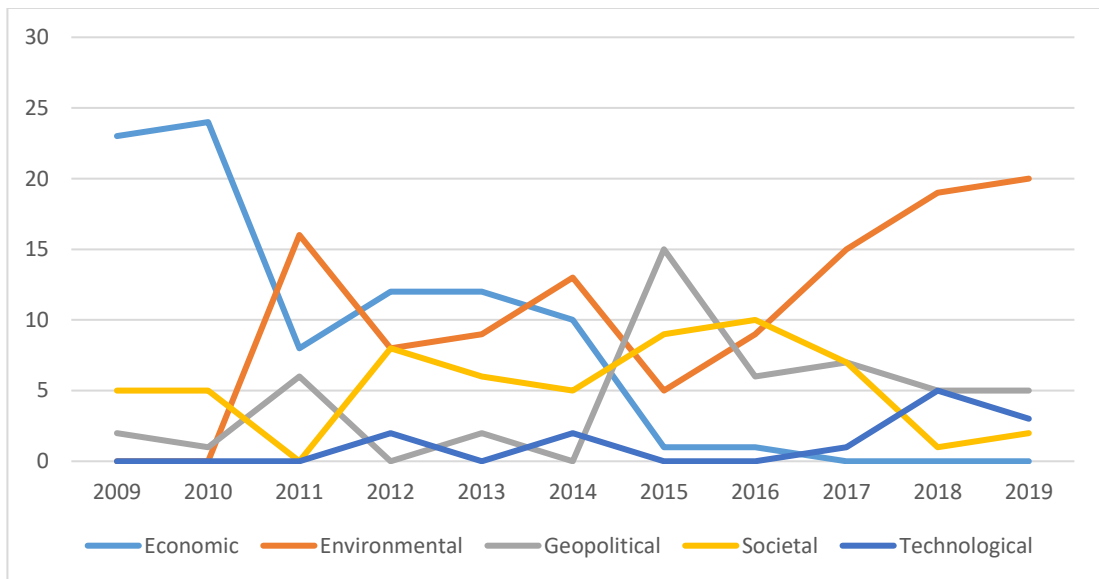
Figure 2: Variation of five risk categories from 2009 to 2019

When we zoom in to the category of environmental risks, the related risks are; Extreme weather events, Failure of climate change mitigation and adaptation, natural hazards. These data indicates that the domination of the world risk matrix has moved on to the environmental risks. Hence addressing environmental risks and managing the risks related is a world necessity. For that a multidisciplinary input and actions are a must whereas engineering input is required to lead the problem solving mechanisms.

It is required to understand the current context and impact towards the focused areas (The research scope is discussed in the next section, research gap) as a preliminary action. From the available data around the world for Natural hazard induced disasters were hence reviewed for the last data available year as follows and completed that review with the disaster impact on Sri Lanka.

The Munich Re NatCatSERVICE reported 850 natural hazard induced disaster events in the year 2018. Geophysical disaster events such as earthquakes, tsunamis and

volcanic eruptions adjudged for 5% of the total disaster events. Storms made up 42% of the events, whereas floods, flash floods and landslides accounts for 46%, while 7% fell into the categories of heat, cold and wildfire. From these events 43% occurred in Asia, while 20% in North America, 14% in Europe and 13% in Africa. Other regions accounted for 10% of the events. [3]

163 natural hazard induced disasters were reported across the American continent (including Central America and Caribbean) of which it was reported 800 deaths and an overall loss of US$ 82bn. Europe experienced 113 events and had to bear an economic loss of US$ 16bn mainly in the agriculture and forestry sector. Due to major flood events across the African region there were 1200 deaths recorded from 100 events. The overall loss estimated for the African region is at US$ 1.4bn. Australia and Oceania experienced over 40 events in the year 2018 which caused an overall economic loss of US$ 1.5bn. [3]

Asia experienced an overall loss of US$ 59bn in the year 2018 due to natural hazard induced disasters. A total of 7,750 deaths were recorded from Asia which accounts for 74% fatalities globally. [3] The above presented figures indicate the impact from natural hazard induced disasters around the world during a single calendar year from the available year.

When it comes to Sri Lanka, being a tropical island situated between latitudes 5°and 10°N, and longitudes 79° and 82°E in the Indian Ocean has weather very sensitive to the changes in the Bay of Bengal. The climate of Sri Lanka is dominated by topographical features as well as the Southwest (May - September) and Northeast (December – February) monsoons. Other than those two monsoons Sri Lanka do experience first inter (March – April) and second inter (October – November) monsoon seasons. The overall wind patterns of the monsoon seasons as well as the changes in the timeframes are possible and depend upon the behavior patterns of the Bay of Bengal. [4]

Most of Sri Lankan natural hazards are caused by hydro-meteorological hazards such as floods, high winds, landslides, etc. of which floods are most predominant. Since 1965, due to the floods, 224,760 houses were damaged. Whereas 128,705 houses damaged due to high winds and, 105,293 houses due to tsunami and 14,761 houses from landslides. Throughout the latest four decades, floods have been the main tragedy that affected the most number of families in Sri Lanka. At existing conditions, flood risk reduction is taken into consideration by pertinent authorities taking extenuation actions to save lives and properties. [5]

As mentioned, southwest and northeast monsoons account for a major share of annual rainfall [4]. When perceiving the flood pattern of Sri Lanka for the preceding three years, the highlighted factor is the May flood, which starts being a cyclic hazard for the past three years. In 2016 total affected people from the May flood were 340,000 whereas in 2017 it was 630,000. When it comes to 2018 during the first week of the flood total impact was 45,680 people. [6]

The 2004 Indian Ocean Tsunami is identified as one of the most fatal disaster event in the recent history. There are a number of reasons for this identification. Total number of deaths, geographical impact, and the total damage of the event are such. 2004 IOT impacted over two hundred and thirty thousand (230,000) deaths across more than fifteen countries through Asia and Africa [6]. 2004 Indian Ocean Tsunami marked from an earthquake of Mw 9.3 which is identified as the first extreme earthquake since 1964 [7]. Sri Lanka was amongst the nations that were severely affected, where the tsunami impacted four-fifths of the coastal belt of Sri Lanka. In Sri Lanka 2004 Tsunami impacted over twenty nine thousand (29,729) deaths, and it was calculated later that the event caused over eighty eight hundred thousand (889,175) people and over seventy nine thousand (79,100) houses to be replaced and resettled [8], [9].

Floods and landslides were the natural hazards largely affected prior to the 2004 Tsunami. The country was not prepared to face a Tsunami event in the year of 2004 majorly since country had not faced or encountered natural hazard of that phenomena [10]. That was identified as the major reason for the high number of losses, which created the vulnerability explosion of not possessing any customary Tsunami Early Warning Mechanisms [11].

The negative impact connected to these disasters create the universal need of minimizing the impact of natural hazards. There are a number of mitigating mechanisms, Disaster Management Mechanisms, policies, plans globally, regionally as well as nationally in place to manage and reduce the losses and impact created by natural hazard induced disasters. Further context on the Disaster Management Mechanism formation and utilization in Sri Lanka and global level is presented in chapters 3 to 6 of the thesis.

With the above context understanding we can define the research gap and identify the research objectives and define methodology to achieve the objectives.

1.2 Research Gap

From the above context understanding we can identify two key observations.

First is that the natural hazard induced disasters are a major risk, a risk which is growing in impact and likelihood.

Second is that the recent history indicates impactful losses already incurred (total economic loss of US$ 160bn in the year 2018) [2].

These two observations leads to the need of mitigating natural hazard induced disasters. To mitigate disaster management mechanisms are required to be implemented, evaluated and updated.

A recent research finding indicates that even though there exists Disaster Management Mechanisms, a mechanism to evaluate the effectiveness is still in the making, which creates a certain unclearness on the direction of the effectiveness of the framework.

With this research finding a number of questions arise whether the need to mitigate the natural hazard induced disasters is addressed well enough. And also how well a system can respond to a disaster risk, whether the system is prepared enough to respond to a disaster, are key questions remained unanswered.

In this regard the research study based to address this nature of disaster risk management mechanisms in an engineering approach.

1.3 Research scope

Understanding the existing disaster management mechanisms was a preliminary requirement in developing a solution for the given question. For that the overall picture of hazards, systems, mechanisms and process used are required to be understood. It was observed that the disaster management mechanisms do have differences in terms of approach and implementation in different countries. Hence a review was conducted to select few disaster management mechanisms.

Given the fact that the research work is utilizing from Asia and more than 40% of the disasters are occurred in Asia, the research on understanding the disaster management mechanisms was focused on Asian countries. Sri Lanka, Myanmar and Maldives are three countries selected based on the following facts.

Asian continent compromised with two types of countries based on the geography. Nations compromising islands (24 countries of such) and continental nations with offshore islands (8 countries of such) [12]. From this context two islands and one continental nation was selected. (Sri Lanka and the Maldives as islands and Myanmar as a continental nation)

Hazard profiles of Sri Lanka, the Maldives, and Myanmar have similar attributes. Floods, Abrasion and cyclones are frequent natural hazards whereas Tsunami was the highest impacting natural hazard induced disaster experienced in recent history. [13]

Sri Lanka, the Maldives and Myanmar do have similar governing conditions. It is observed by several researchers that the countries do carry high power distance. The cultural and social patterns lead to such nature are also similar in three countries. Masculinity nature and the collectivist culture is quite visible. [14],[15]

With these three facts Sri Lanka, the Maldives and Myanmar were selected as three case study countries to study the disaster management mechanisms.

Another important aspect was considered before concluding the selection of research scope. That is the research finding that coastal communities are the most vulnerable sector to natural hazards. Because coasts are among the most dynamic environments on earth as well as the coastal regions are among the highly dense human communities. [16]

Hence the research work is scoped to the disaster management mechanisms of coastal communities in Sri Lanka, the Maldives and Myanmar.

1.4 Objectives

There are three objectives defined to address the research gap.

1) Identifying elements of disaster management mechanism including the policies and institutional mechanisms.

2) Developing evaluation frameworks to recognize the efficiency and effectiveness of a certain Disaster Management Mechanism.

3) Developing a network mapping model to predict the behavior of coastal system in disaster management and identifying a model Disaster Management Mechanism as a risk diagram.

2 LITERATURE

2.1 Project Management

Project Management Body of Knowledge, 6th edition (PMBOK Guide) from Project Management Institute is used as the fundamental literature source in reviewing the literature on project management. [17] All terms referred here are extracts from the PMBOK Guide. Definitions of a project and the project management are included in the annex on PMBOK review.

2.2 Risk Management

2.2.1 PMBOK Guide overview

This section reviews the literature from PMBOK Guide on Risk Management. According to the guide the objective of a project risk management is to increase the impact of positively effecting risks and to minimize the impact of negatively effecting risks.

There are 7 processes in the project risk management according to the PMBOK Guide.

- Plan risk management

- Identify risks

- Perform qualitative risk analysis

- Perform quantitative risk analysis

- Plan risk responses

- Implement risk responses

- Monitor risks

Plan for risk management should be conducted at the point of conceive and completed at the early stages of the project. Plan risk management process defines how to conduct the project risk management activities. The output from the plan risk management process is the risk management plan. The risk management plan includes but not limited to; risk strategy, methodology, roles and responsibilities, funding, timing, risk categories, stakeholder risk appetite, definitions of risk probability and impacts, probability and impact matrix, reporting formats, and tracking. In order to prepare the risk management plan there are different tools and techniques to collect data such as expert judgements, data analysis, and meetings.

In the second process of risk management, identify risks, the process of identifying project related overall risks, sources of risks is done. Risk register, risk report and updates on the project documents are completed after the process.

The third process, perform qualitative risk analysis is conducted with the objective of prioritizing individual project risks for further analysis. Focus is on the high priority risks during this process. The process is not limited to the initiation stages of the project, throughout the project qualitative risk analysis is performed. Assumption log, issue log, risk register and risk report are required to be updated as output of the qualitative analysis.

Quantitative risk analysis process is the numerical analyses of the project risks. This process is not required in every project but when used, it's utilized throughout the project. Combined effects of the identified individual project risks and other sources of uncertainty on overall project objectives is identified from the process.

Next process, plan risk response is the process of developing strategies, developing options and planning for the possible actions with the relevant stakeholders. The process includes and allocates necessary resources, activities in to the project documents. There are five strategies to be considered dealing for threats; escalate, avoid, transfer, mitigate, and accept. Similarly for opportunities there are five alternative strategies to be considered; escalate, exploit, share, enhance, and accept.

Implement risk response is the process which prepares the change requests. In this process the implementation of risk response plans is conducted while ensuring to address the overall project risk exposure, minimize individual project threats, and maximize individual project opportunities.

Final process of the risk management is the risk monitoring. Monitoring of the implementation of risk response plan and controlling of the implementation is done here. Also identifying and analyzing new risks and evaluating the overall process throughout the project are key activities.

The above is a summary of risk management knowledge review and summary from the PMBOK Guide. There are further literature available for risk management concepts as illustrated in the following sections.

2.2.2   Risk Assessment

Risk assessment is a frequently used literature terminology in the risk management area. Risk assessment represents major parts of the risk management process and generally referred with risk management, yet risk assessment is a subset of risk management as discussed below. One of the key importance of risk assessment study is it enhances and facilitates the mathematical approach in risk management.

According to the ISO guide 73, there are three distinct components in the risk assessment, namely; Risk identification, Risk analysis, and Risk evaluation. It enhances the importance of risk assessment in the risk management process, as illustrated in the Figure 3. [18]
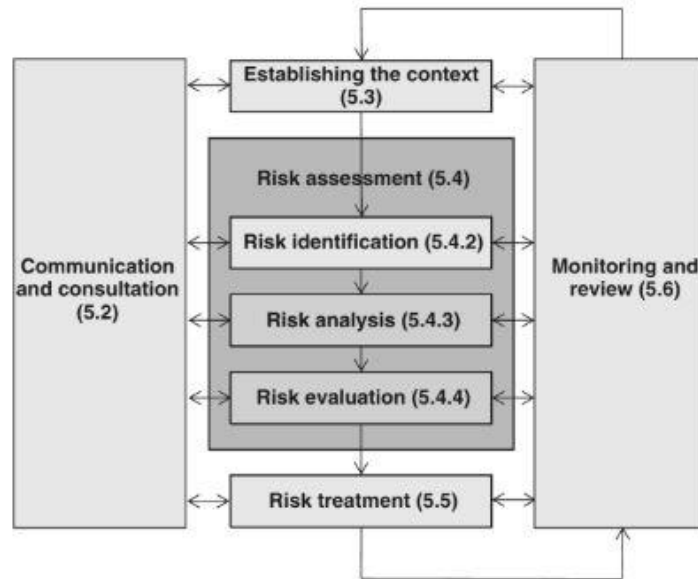
Figure 3: Risk Management Process [19, p. 31]

James Murphy 2016 illustrated risk assessment as a systematic examination of a task, process, system, conducted with the objective of finding significant hazards, whereas the risk of system getting harmed, and concluding further control measures to mitigate and reduce the risk to an acceptable level. [20] There he has focused on the negative impact of risk assessing only. The positive risk assessment is left out in this definition. Further he has completed the risk assessment in identifying templates to do the risk assessment. Again its limited or rather focused only on office working environments.

Ostrom and Cherly 2019 in their book on Risk Assessment, identifies risk assessment as a systematic approach. The vulnerability identification of a system is the key output of a risk assessment as per their review. [21] Hence they discuss risk assessment as a systematic process which ends before risk treatment.

A direct definition of risk assessment was provided by Marvin 2013 in his book on Risk Assessment: Theory, Methods, and applications. He reviews risk assessment as the overall process of risk analysis and risk evaluation. It identified that when a risk analysis and risk evaluation is conducted in a joint process, defined as the risk assessment. This definitions are more in general form for risk assessment when compared to the Murphy.

If these definitions compared with the PMBOK Guide risk management process, risk assessment represents the identify risks, qualitative and quantitative risk analysis processes. It is debatable whether the plan risk responses process includes in the risk assessment.

The risk assessment study area generated number of mathematical models on risks and risk management. David Vose in his book on "Risk Analysis: A quantitative Guide" identifies two basic parameters to rank risks. He identifies a base measure of risk as

probability * impact. A major drawback from this approach is the space provided for mitigation. It is argued that if the mitigation measures are provided that the impact parameter indicates that. Yet again it is identified as a measure of hazard. Hence the approach of David Vose on risk ranking is more of a hazard ranking as he later defines from his work. [22]

C.B. Chapman defined risk as a measure of hazard and vulnerability in 1991. His literature defined a parameter of vulnerability which gives space for the exposed system. Again in this definition too the space provided for mitigation measures is not observed.

$$Risk = Hazard \times Vulnerability$$

Equation 1: Risk Equation by Chapman

Chapman defines hazard as a potential risk in its untreated form, hence includes the impact on the highest level and allows the probability parameter to be included in the hazard parameter. [23]

The book on "Index for Risk Management" by Greove, Poliansek and Vernaccini in 2015 illustrates risk in three parameters. [24]

$$Risk = Hazard \times Vulnerability \times Deficiencies\ in\ Preparedness$$

Equation 2: Risk Equation by Greove

Deficiencies in preparedness is a parameter they introduced in order to accommodate mitigation measures in the risk analysis. The parameter here is the reciprocal of capacity as identified by Rafetry in 2003. Rafetry identifies risk as a measure of three parameters, including capacity. [25]

$$Rsik = \frac{Hazard \times Vulnerability}{Capacity}$$

Equation 3: Risk Equation by Rafetry

Hazard and vulnerability parameters indicate the exposed nature and the availability of hazards for a system. Where as in the same time capacity measure illustrates the risk mitigation, absorption capacity of a system. This is a requirement in the context of natural hazard induced disasters. For this research this definition from Rafetry is used, and is referred to as the Raftery equation.

2.2.3 Risk identification

There are number of methods, approaches available and discussed in the literature on risk identification methods. There are number of aspects in this regard are discussed here. A one major review point is the applicability of these approaches in the natural hazard area.

Georgi Popov listed risk identification methods in his book as brainstorming, checklists, regulations, consensus industry standards, experts, job hazard analyses, job safety analyses, accident investigation, injury records, and insurance claims [26]. Also the ISO 31010 guide illustrated 31 formal risk identification methods[19].

The PMBOK guide illustrates that the identified methods are a guide only to the risk identification process. Especially in the area disaster risk management the risk identification activities can be differed and the only major input can take is that the expert inputs in selecting any mechanism is required as a basic step.

2.2.4 Risk Analysis

There are two major parts identified in the risk analysis as qualitative and quantitative risk analysis. The comparison of the both was reviewed done on the PMBOK Guide overview Section.

This section on risk analysis compromised with assessment models available for required parameters.

2.2.4.1 Hazard assessment

There are number of literature available and models in practice for hazard assessment. FEMA model and SMUG hazard priority system are such two mechanisms widely is use.

FEMA model uses four criteria in the evaluation for risks. Namely history, vulnerability, maximum threat, and probability.

It can be identified that there are sufficient hazardous conditions and vulnerability to cause a disaster. Unless these conditions no longer exist, or reduced considerably, a similar emergency may occur again. History criteria evaluates this context.

Vulnerability criteria determines the number of people and the value of property, based on factors such as population densities, vulnerable groups (aged, disabled, and children), and location of population groups, property and vital facilities.

Most severe event possible with the greatest impact is assumed in the maximum threat, which is expressed in terms of human casualties and loss of property.

Probability criteria in the FEMA model evaluates the likelihood of an event occurring. There is a scoring mechanism here which includes all the criteria. Evaluation from low, medium and high indicates the scores and for each criteria a weighting mechanism is there to finalize the analysis mainly on a numerical analysis.

SMUG hazard priority system uses a direct comparison of possible hazards using a rating system. Seriousness, manageability, urgency, and growth of each hazard is rated. The SMUG system produces an output of a comparison.

2.2.4.2 Vulnerability Assessment

Single dimension of susceptibility approach to vulnerability and sector approach to vulnerability are two models widely used in the vulnerability assessment.

Physical, human, economic, environmental, functional, and administrative are six critical parameters in the simplified approach of vulnerability assessment used in the susceptibility approach.

The sector approach conducts the vulnerability assessment in three dimensions, namely; susceptibility, sectors and scale of consideration. The model proposes the differentiation within each sector in terms of six areas related to susceptibility, namely human, physical, socio-economic, environment functional and administrative. These areas can be linked to the factors identified as increasing the susceptibility of communities to the impact of a hazard. Third dimension targets the scale of consideration from a household to national level. The advantage of this approach, in particular from a policy point of view, is that it promotes the effective assignation of responsibilities relating to the reduction of vulnerabilities. The method requires vast amount of data to conduct the assessment.

2.2.4.3 Capacity Assessment

Capacity is a terminology used in identifying knowledge, capacities and skills to face impacts of hazards, which are available within people, community, or organizations. UNISDR defined Capacity assessment as a process of reviewing the capacity of community or group in achieving the desired goals. [27]

Capacity assessment is done in three levels; in individuals, in organizations and in the overall enabling environment.

Enabling level includes the rules, governing policies in the broader system within government systems. Hence here it is assessed the capacity in all sectors as engagement in a broader manner.

Internal structures, systems are assessed in the organizational level. Also in the individual level skills and competencies of people which allows them to perform during risk actualizations. [28]

2.2.5 Risk Management Frameworks

As a summary the overall risk management plan can be illustrated as in the Figure 4 with the above literature review.
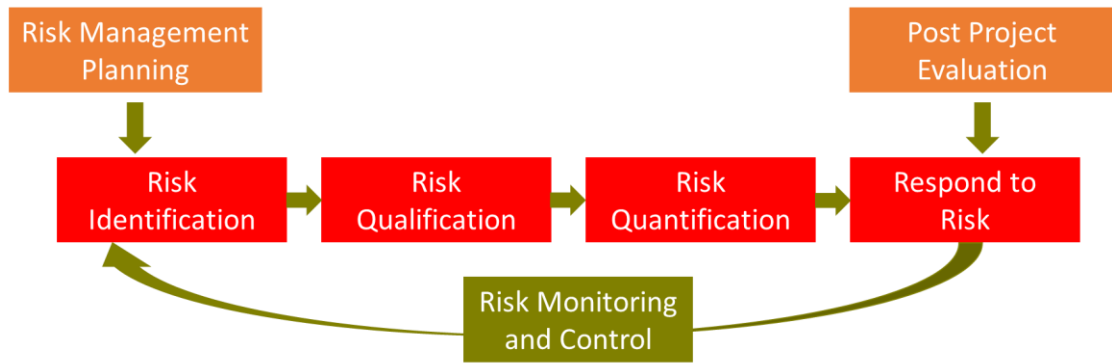
Figure 4: Risk management framework [17]

2.3 Risks and Disasters

The question of the practical use of identified terminologies and academic knowledge on risk management to the disaster management, was tried to be first address by creating the following ideology on disaster risk management framework. The framework is illustrated in the Figure 5.
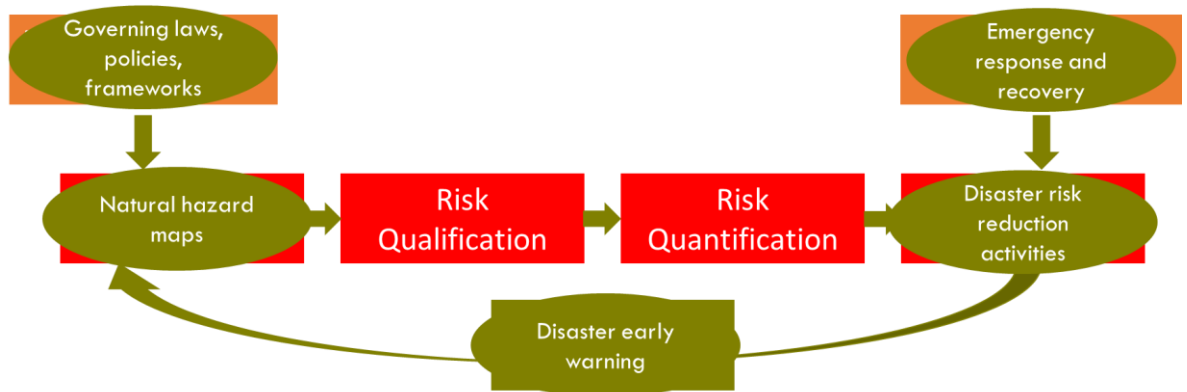
Figure 5: Ideology of disaster risk management framework

Risk management planning process can be identified as the governing laws, policies and frameworks in the field of disaster risk management. Risk identification can be identified as the natural hazard maps generation and related activities. Respond to risk can be identified as the disaster risk reduction activities. Post project evaluation is being terminologically identified as the emergency response and recovery in disaster risk management. Finally risk monitoring and controlling can be identified as the disaster early warning and related activities.

2.4 Country Comparison

Further moving in to the disaster management mechanisms and focusing into the case study level disaster management, a review was conducted on the case study country comparison.

First comparison was done based on the cultural aspects of Sri Lanka, Myanmar and Maldives.

All three countries are compromised with a collectivist culture. The masculinity nature and the high power distance of the countries defines the social and community behaviors of the countries. Further analysis of these facts, in detail, were used in preparing the evaluation frameworks of the research work.[15]

Next comparison was on the geological features, and the population densities of the countries as illustrated in the Table 2.

Table 2: Country comparison

	Sri Lanka	Maldives	Myanmar
Coastline Length	1340 km	1129 km	1930 km
Total Population	21,336,833	532,668	59,094,870
Coastal Population	4,355,000	532,668	1,544,000

It is observed that the coastal population is a major part in Sri Lanka and Maldives and also in Myanmar in absolute values.

2.5   Disaster Management

UNISDR defined disaster the actual historic event which, is a serious disruption and make a system of community disturbed. Disaster event impacts to human life, infrastructure and environment where the community system's own resources are not enough to cope. [27]

Disasters can be categorized in number of ways. Natural hazard induced disasters, human made disasters is one of such. Also disasters can be categorized as; Geophysical, Hydrological, Climatological, Meteorological, Biological etc. Examples for such and the impact from recent history of such are presented in the context part of the introduction of the thesis.

In this background, disaster risk management is the defined process of using administrative policies, frameworks etc. to execute actions in order to minimize the impacts of disasters. This aims to avoid, mitigate, or transfer the effects of the disasters towards the community systems.

Disaster management can be better understand in number of stages. As illustrated in the Figure 6 [29] disaster management cycle steps can be defined for the disaster cycle as pre disaster, response stage, and the post disaster. Disaster risk reduction, disaster risk management establish as steps from pre disaster. Whereas rescue and relief work establish under the response stage. Also under the post disaster stage, rehabilitation and future disaster risk management activities are listed. [30]
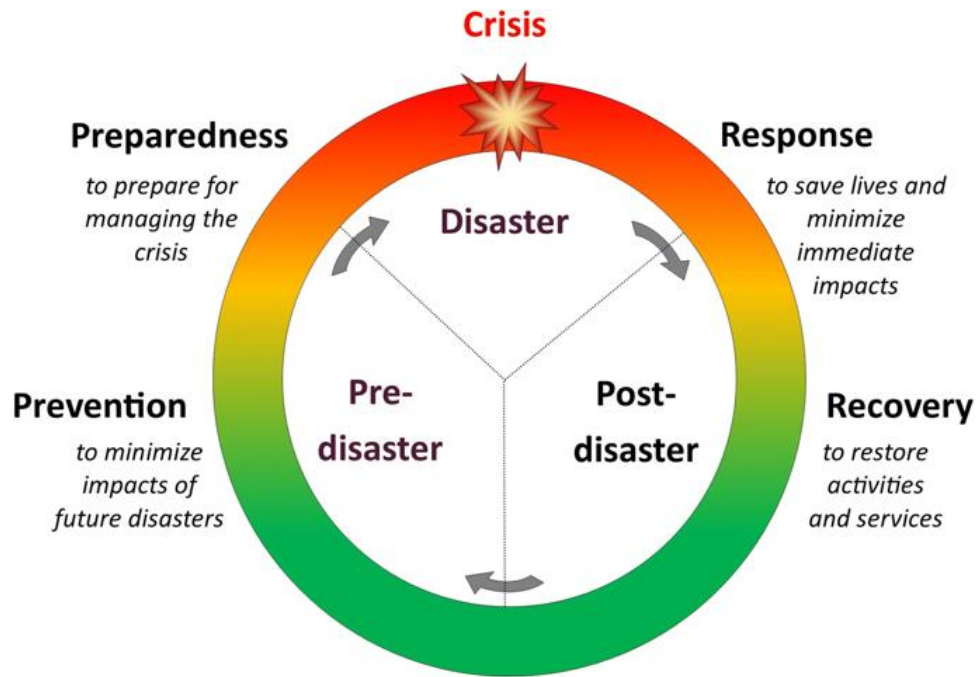
Figure 6: Disaster Management Cycle [29]

When developing the research work the disaster stages were further analyzed and illustrated as in the framework development section of the thesis.

Disaster risk reduction and resilience are two concepts where the disaster management strategies are developed. Reducing the exposure to hazards, management of resources proactively for the mitigation of risk as the underline goal is risk reduction. [30] Whereas resilience is denotes the ability to cope against a disaster. And eventually for a community potential to build back after a disaster event.

There are number of frameworks globally available to support the disaster management mechanisms. With the guidance of the global frameworks local framework are developed and in operation. This section identifies and reviews the globally available Disaster Management Mechanisms. And also identifies the disaster management mechanisms in the means of policies and institutional arrangements in Sri Lanka, Myanmar and Maldives.

2.5.1 Disaster Management Global Frameworks

The foremost international framework related to disaster management is the Sendai Framework, which was adopted during the Third United Nations, World Conference on Disaster Risk Reduction held in Sendai, Japan from 14th to 18th March 2015. . The Sendai Framework is the successor of Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. It is the first major agreement of the post-2015 development agenda, with seven targets and four priorities for action.

The Sendai Framework mainly focus on risk reduction and resilience which is a common element highlighted in all the 2030 development agendas adopted by all member states of the United Nations. Addis Ababa Action Agenda on Financing for Development, the Sustainable Development Goals, the Paris Agreement on Climate Change, the Agenda for Humanity and New Urban Agenda are some of the other agendas which focus on resilience.

The Sendai Framework introduces seven global targets which represent a means to quantify and qualify the "substantial reduction of disaster risk and losses in lives, livelihoods, and health, and in the economic, physical, social, cultural, and environmental assets of persons, businesses, communities and countries" indicated in the expected outcome.

An overall summary of the Sendai framework is provided in the Figure 7.

Figure 7: Sendai framework [31]

In the Sendai framework 7 global targets of the framework includes reducing the global mortality and affected people rates, economic loss reduction, infrastructure damage reduction, International Corporation and increasing the early warning systems usages in brief. It is intended that these targets are achieved in all four levels, Global, Local, National and Regional. In achieving such the roles and responsibilities of the stakeholders and guidance on the networking among governments and organizations is provided with the framework.

Enhancing disaster preparedness for effective response, rehabilitation and reconstruction, in order to build back better are principals within the Sendai framework which focuses on disaster risk reduction through mitigation and preparedness.

2.5.2 Disaster Management Mechanism of Sri Lanka

In this chapter (as well as in the next two chapters on Myanmar and Maldives disaster management mechanisms), the presented data are gathered from the institutional survey conducted during the case studies. The chapter is formed firstly as the policies and then identified the institutions empowered from the policies.

2.5.2.1 Policies

The institutions and legislations related to Disaster Management Mechanism of Sri Lanka have undergone several changes since 1977. Where since 1977 to 1988 it was the responsibility of Ministry of Social Services. Then the responsibility was carried by the ministry of Rehabilitation, Reconstruction and Social Welfare till the year 1994. Where in the years 1994, 1995 and in 1996 the responsibility was shifted from Ministry of Health and Social Services to Ministry of Social Services to Disaster Management Center of Sri Lanka/ Department of Social Services respectively. From 1996 to 2005 a dedicated body to manage disasters was first recognized through the establishment of a National Disaster Management Centre (NDMC) under the Ministry of Health, Highways and Social Services.

These responsibility transfers were mainly due to the structural changes in the government of Sri Lanka.

Then with the establishment of the Disaster Management Act in 2005, National Council for Disaster Management led the preparedness activities while the Ministry of Disaster Management had the direct responsibility in managing disasters. [32], [33]

The overall changes in the responsibility of Disaster Management is presented in a timeline from the Figure 8.
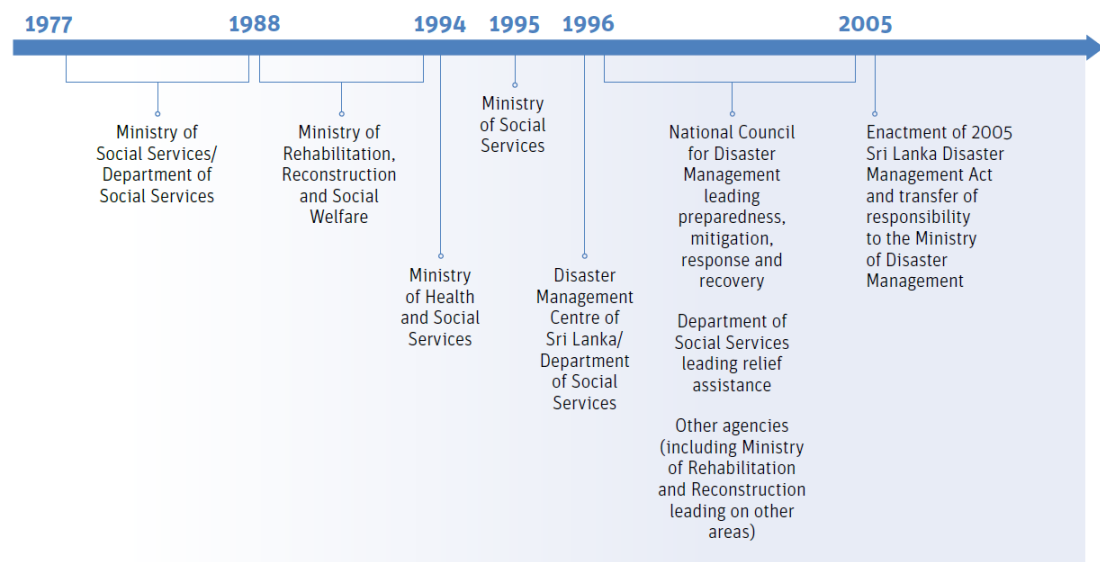
Figure 8: Disaster Management History in Sri Lanka.[34]

Following are the formations of acts and policies in a timely order.

- Reconstruction and Rehabilitation Fund Act, No. 48 of 1993: Used to provide relief to persons affected, reconstruct of property and for rehabilitation.

- Disaster Management Act No. 13 of 2005: provides the institutional structure and governs the disaster management structure. And also defines the National Council for Disaster Management (NCDM) and Disaster Management Centre (DMC).

The Disaster Management Act of 2005, provided institutional structure to be adopted to facilitate the disaster risk management. The act assigns three broad functions to the NCDM. Policy formulation/planning, Monitoring and Ensuring disaster preparedness are the three functions. In addition the act authorize the relevant authorities to act upon the requirement such as empowering the president to declare a state of disaster.

After the act of 2005 there were number of policies, plans compiled with accordance to the international frameworks available and as per the timely needs. Following are the compiles of such nature.

- National Disaster Management Policy: prepared in 2010 according to the Hyogo framework for action.

- Ministry of Finance and Planning – Budget Circulars No. 152 (I) (II) and (III): Issued in 2013 and 2014: to mitigate the duplication of funding.

- National Disaster Management Plan: prepared for 2013-2015. Provides guidance to the formulation of the disaster management plans in all levels of administration.

- National Emergency Operations Plan: Provides guidelines for emergency preparedness (2015)

- Sri Lanka Comprehensive Disaster Management Programme: The action plan for 2014-2018

- National Adaptation Plan for Climate Change Impacts of Sri Lanka: is prepared for 2018-2025 in line with United Nations Framework on Climate Change.

- Sri Lanka Disaster Management Plan: prepared in accordance with Sendai Framework for the years 2018-2030.

2.5.2.2 Organizational Structure
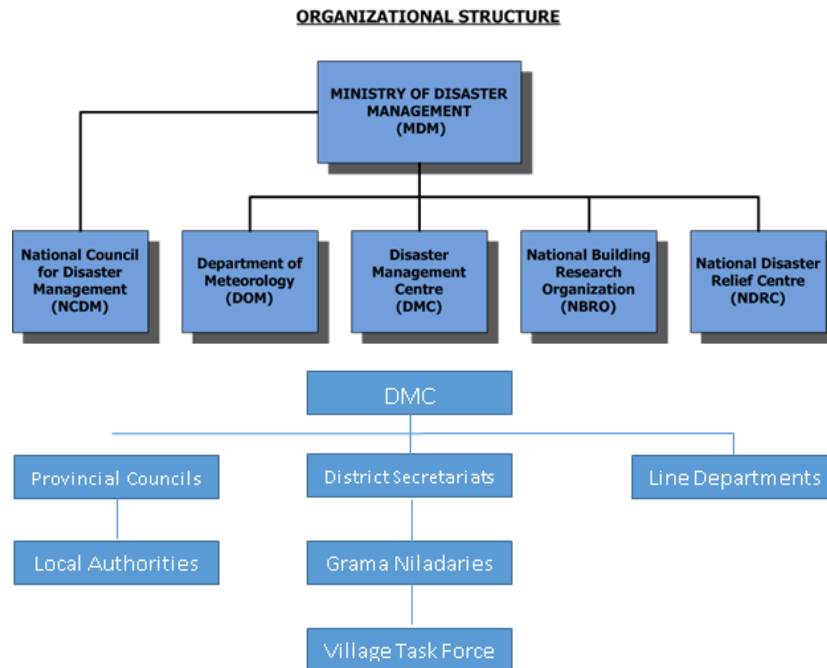
Figure 9: Upstream Organizational Structure of Sri Lanka

2.5.3 Disaster Management Mechanism of Myanmar

2.5.3.1 Policies

Myanmar Disaster Management Mechanism (Herein after DMM) complied from;

a) Disaster Management Law, 2013. (The pyidaun gsu Hluttaw Law No. 21,1013)

b) Disaster Management Rules, 2015. (Notification no. 22/ 2015 from the Ministry of Welfare, Relief and Resettlement)

a) Disaster Management Law, 2013, compromised with 9 Chapters as follows.

1) Chapter 1: Title and Definition

This chapter embarks the name of law and then defines the terms of State, Disaster, Disaster Management, Disaster Risk Reduction, Resource, National Committee, Local Body, International Organizations, Foreign regional organizations and Victims.

2) Chapter 2: Objectives.

There are 5 objectives identified in this chapter. Implementation and formation of programs and bodies. Coordination of different stakeholders, conserving the environment, and provisions management are specified as objectives.

3) Chapter 3: Formation of National Disaster Management Committee and its Duties and Powers

The union government is empowered to form and reform the National Disaster Management Committee (Herein after NDMC) from the clause No. 4.

The clause No. 5 identifies 31 duties and powers of the NDMC. Laying down policies, forming supporting bodies, delegating duties to the relevant stakeholders, coordination with stakeholders, reporting, guiding and supervising are some of the key duties and powers mentioned.

The provision No. 6 empowers The Ministry of Welfare, Relief and Resettlement to undertake the related office work.

4) Chapter 4: Formation of Disaster Management Bodies and its Duties and Powers

The Union government and the region or state government is empowered for formation of the disaster management bodies from clauses No.7 and No.8.

The clause No. 9 defines the duties and powers of the National disaster management bodies. The actions and duties falls accordingly to implement the disaster management under the guidance of NDMC.

5) Chapter 5: Declaration of being a disaster affected area

Clauses No. 11 and No. 12 empowers the President in declaring area as a disaster affected area.

6) Chapter 6: Disaster Management

This chapter includes 6 clauses from No.13 to No. 18 which defines the functions on disaster management as follows.

Clause No. 13: Defines the acts and powers of stakeholders in disaster management.

Clause No. 14: Preparatory measures for disaster risk reduction before disaster.

Clause No. 15: Preparatory measures to be organized before disaster in the area where is likely to strike the disaster.

Clause No. 16: Preventive measures to be carried out in the area where is likely to strike disaster before the disaster

Clause No. 17: Actions when the disaster strikes, emergency responses including search and rescue.

Clause No. 18: Rehabilitation and reconstruction activities to be carried out after the disaster.

7) Chapter 7: Disaster Management Fund

NCDM and Region or State bodies are empowered and defined the actions on establishing, reporting, budgeting, allocating, and auditing the funds under the clauses No. 19 to No.24.

8) Chapter 8: Offenses and Penalties

From clauses No. 25 to No. 31 defines the types of offenses and the repercussions of each act.

9) Chapter 9: Miscellaneous

Exemption of tax for provisions, use of uniforms, compensation entitlement, issuing of notifications are some of the entitlements listed under this chapter.

b) Disaster Management Rules, 2015

1) Chapter 1: Title and Definition

2) Chapter 2: Functions and duties of the Ministry of social welfare, relief and resettlement

3) Chapter 3: Functions and duties of relevant ministries, government departments, government agencies

4) Chapter 4: Functions and duties of the department

5) Chapter 5: Disaster management plans

6) Chapter 6: Declaring a state of disaster affected area and its duration

7) Chapter 7: Disaster preparedness and prevention for disaster risk reduction at the pre-disaster phase

8) Chapter 8: Emergency response activities including search and rescue during the disaster stage

9) Chapter 9: Rehabilitation and reconstruction during the post disaster phase

10) Chapter 10: Communication, collaboration with the assisting international actors

11) Chapter 11: Maintenance, and disposal of the national disaster management fund

12) Chapter 12: Miscellaneous

2.5.3.2 The organizational structure

There are five administrative levels in the Myanmar system as illustrated in the Figure 10.
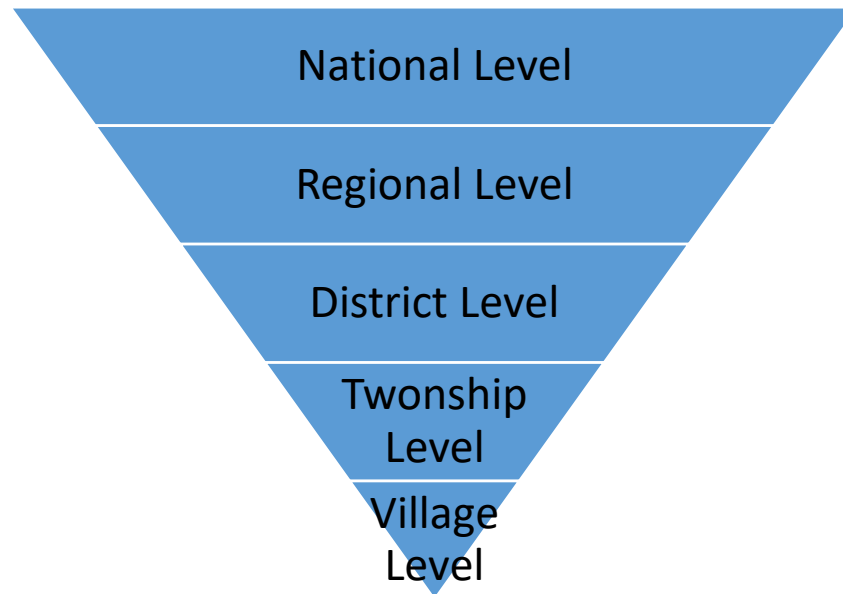
Figure 10: Administrative Levels in the Myanmar system

In each level under the provisions from disaster management act, there are working committees formed. The working committees are;

1. Disaster management work committee

2. International relations work committee

3. Financing and financial management work committee

4. Search and rescue work committee

5. News and information work committee

6. Rehabilitation and reconstruction work committee

7. Health care work committee

8. Initial need assessment/ damage and lost verification and need identification

9. Livelihood restoration

10. Environmental conservation

11. Security work committee

12. Logistics work committee

2.5.4   Disaster Management Mechanism of Maldives

2.5.4.1   Policies

The Disaster Management Act, 2005 of Maldives enables and empowers the disaster management mechanism of Maldives. Basic aims of the policies can be listed as follows.

- Policies aim to shelter the people from natural hazards as well as man-made hazards.

- To effectively use frameworks for disaster risk reduction.

- To reduce disaster risk and to adapt a preparatory national strategy, to identify responsible parties to manage disaster risk, and to identify their responsibilities.

- To provide assistance at emergency situations and to provide assistance on the relief efforts, to incorporate such guidelines to coordinate such assistance.

- To state the roles and responsibilities of the City Councils, Atoll Councils, and Island Councils in reducing disaster risk and mitigation in emergency situations.

- To create awareness among the people in reducing disaster risk and mitigation in emergency situations, and to incorporate guidelines to protect the people from such dangers and enhance coping capacity.

- To make sure national projects are designed, planned and implemented by keeping the disaster management guidelines as a basis to make sure projects are sustainable.

- To enhance the community empowerment for people to be able to accountable and act upon disaster events for recovery and emergency situations.

Other than to the act there are three guidelines in place to drive the disaster management mechanism of Maldives. The three guidelines are;

1. Community Based Disaster Management (CBDRM) Framework

2. National Internally Displaced People (IDP) Framework

3. Mainstreaming Disaster Risk Reduction into local development (Country report and action plan)

1. Community based Disaster Management Mechanism

The framework is developed by the lead of Maldives National Disaster Management Center (herein after NDMC) on 2014. The (CBDRM) is of two parts. First part of it is the analysis of country assessment and a comparison assessment on institutional arrangement, human capacity, technical capacity, partnerships, and financial resources. Part two introduce the CBDRR strategy and implementation, monitoring and evaluation mechanisms.

2. National Internally Displaced People (IDP) Framework

This framework defines actions to be followed by local, national and international agencies to assist displaced people during a disaster situation.

3. Mainstreaming Disaster Risk Reduction into local development (Country report and action plan)

This guideline was prepared in 2014 with 6 modules. Concepts, use of tools, planning, developing, linking with local development planning and measuring are the aspects in detail described in the modules.

All of the above three guidelines were prepared when the disaster management act was in progress. Hence the framework was formulated based on the assumption that the act is in place.

2.5.4.2   Organizational Structure
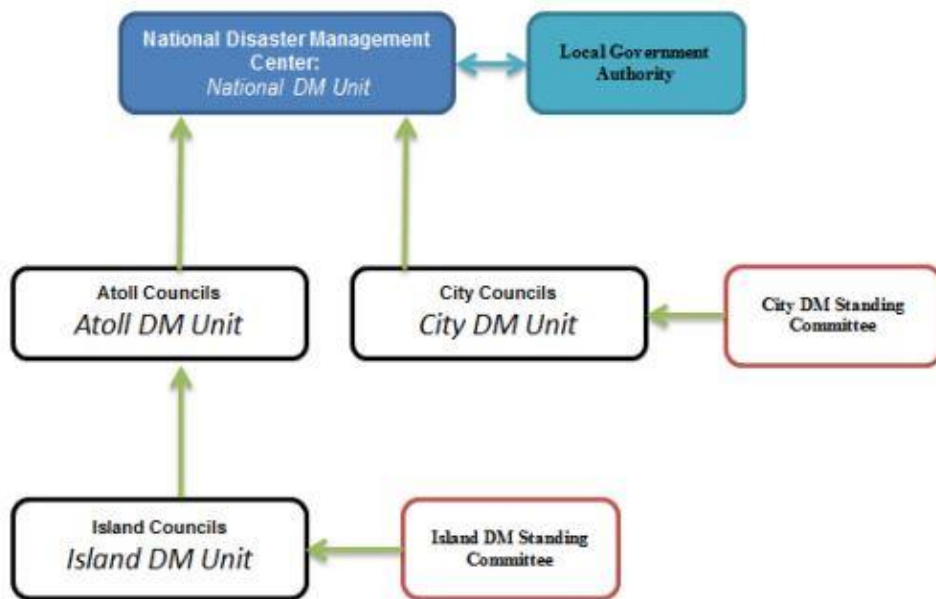
Figure 11: Disaster Management related organizational structure of Maldives

3 METHODOLOGY

To achieve the defined objectives of the research work, methodology was phased out as three segments. Namely; desk study, case studies and the framework development.

Desk study

1. Risk management theoretical review

2. Natural hazard theoretical review

3. Disaster management theoretical review

Case studies (Institutional and community)

1. Myanmar case study

2. Sri Lanka case study

3. Maldives case study

Framework development

1. Evaluation framework development

2. Human - institutional behavior framework development

3. Map of gaps framework development

4. Elements ranking system development

5. Ideal disaster management mechanism development

3.1 Disaster Management Mechanism Evaluation, Framework Development

The evaluation frameworks are developed in accordance with achieving the objective 2 of the research, developing evaluation frameworks to recognize the efficiency and effectiveness of a certain Disaster Management Mechanism.

The objective number two generates mechanisms to achieve the final objective, identifying an ideal disaster management mechanism. The ideal disaster management mechanism includes the gaps identification mechanism, ideal state institutional requirement, risk planning and incorporation of governing mechanisms (Institutions). This final output has to be generated from number of inputs available. Which are the identified disaster management processes, identified stakeholder arrangements, and identified gaps. The gap between the desired output and the input is has to be bridged by understanding the relations among the elements, understanding/evaluating the current state. For that there are number of evaluation frameworks developed as part of the research work.

There are four evaluation frameworks developed as follows.

1. Evaluation questionnaire framework. (Institutional and community survey questionnaire). An initial framework developed from a pilot survey [35] was further developed as two questionnaires.

2. Human – Institutional behavior framework. The framework was developed by referring the Hofstede index [14] on institutional and social behaviors to illustrate the coordination mechanisms and networking environment of institutions and people.

3. Map of gaps in disaster management process. The identified gaps and barriers from disaster management process are mapped with respect to the responsible and related institutions a networking diagram was produced.

4. Institutional ranking system. The system was developed as a method to identify and rank/prioritize institutions empowered from the disaster management policies.

The 4 frameworks were developed as mechanisms to evaluate the elements of the disaster management mechanism. First framework is in place to identify all the relevant aspects of disaster management mechanism and the next three frameworks respectively evaluate the institutional behaviors, barriers and organization of institutions. [36]

3.1.1 Evaluation questionnaire framework

Since the evaluation framework expects to assess the whole spectrum of the Disaster Management Mechanism, in preparation of the questionnaire, the disasters were initially staged in to the three stages of a disaster; Disaster Risk Reduction (DRR) stage, Emergency Response stage and Recovery Stage, as aforementioned [37]. At the same time, facts which serve as the fulfilment criteria of a given stage were identified. Yet the facts are not tangible enough, hence for each fact, relevant attributes were defined. The numbers in Figure 12 are the total of each mentioned.
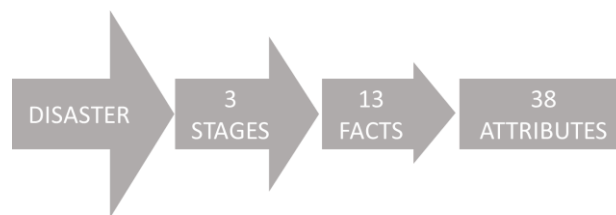
Figure 12: Stages, Facts and Attributes

The first stage of the disaster lifecycle is the DRR stage, and the term DRR implies the outcome of "the sustainable reduction of disaster losses, in lives and the social, economic and environmental assets of communities and countries" [38] which was empathised more by the successor instrument to the Hyogo Framework for Action, the Sendai Framework for Disaster Risk Reduction. DRR stage is compiled with facts such

as ongoing development activities, risk assessment, prevention, mitigation, preparedness, information availability, awareness and early warning [39]. The term "capacity building" includes learning and training as well as the continuous efforts to develop institutions, resources and development of preparedness and awareness. [30] Therefore, three facts were defined to serve the DRR stage: early warning, information availability and capacity building.

Emergency Response is the second stage of the disaster lifecycle, which could be seen as a coordinated multi-agency response to reduce the impact of a disaster and its short-term and long-term results including disaster relief. These relief activities include rescue, relocation, providing food and water, preventing disease and disability, repairing lifeline services such as electricity, telecommunications and transport, providing temporary shelter and emergency health care [40]. Baas et al., 2008 compiled emergency response stage into evacuation, rescuing people and livelihoods, immediate assistance, assessing damage and loss. Also humanitarian assistance in disaster relief is a field of area highlighted in Chawis Boonmee, 2017 and in S. Rajakaruna, 2017. Therefore, five facts were derived for the emergency response stage namely: evacuation, search and rescue, leadership and coordination, provision of humanitarian assistance and initial damage and needs assessment.

The final stage of the disaster lifecycle is the recovery stage which includes the tasks of rehabilitation and reconstruction. Requirement of pre-formed strategies and policies, programmes, public awareness and involvement is required in applying the build back better principle in disaster recovery[30]. Hadi, 2014 and Baas et al., 2008 characterized recovery stage in to following segments respectively: ongoing assistance, recovery, reconstruction, economic and social recovery, ongoing development activities and risk assessment and latter parts it in to Rehabilitation and Reconstruction. Where Rehabilitation includes: Public services, basic social services, basic infrastructure, recovering economic facilities rebuilding settlements and mental rehabilitation. Whereas reconstruction includes: Economy, transportation, telecommunication, social/heritage and institutional. Hence for the recovery stage, five facts were identified which are: provision of early recovery assistance, temporary accommodation and repair, rebuilding houses and buildings, restoration of infrastructural services and re-establishment of sustainable livelihoods.

In overall for the three stages of the disaster cycle, thirteen facts were identified and table provides the individual relevance of each fact to the Disaster Management Mechanism, as a summary. Nonetheless, as it could be perceived that the derived facts are intangible for the most extent. Therefore these facts were furthermore, discretized to have quantifiable attributes, which could be used to assess the fulfilment of each fact in a disaster event as illustrated in the Table 3.

Table 3: Fact relevance to the Disaster Management Mechanism

Disaster Lifecycle Stage	Fact	Relevance to the Disaster Management Mechanism
DRR Stage	1.Early Warning	Includes reliable and accurate forecasting of weather and multi-hazard early warning systems with sufficient dissemination time.
	2. Information Availability	Includes lessons knowledgeable from previous disasters including knowledge on geological and monetary/health risk.
	3. Capacity Building	Vulnerability reduction from any physical capacity increment or people skill capacity development
Emergency Response Stage	4. Evacuation	Includes the identification of evacuation locations previous to disaster event and during the disaster event the need for evacuation and time taken for evacuation is considered.
	5. Search and Rescue	Use of armed forces and their involvement is measured here. The need for rescue and the time taken for such is considered.
	6. Leadership and Coordination	Local leadership and the measurements taken as a community in the disaster event is measured here.
	7. Provision of Humanitarian Assistance	Includes the non-monetary support provided right after the disaster even such as immediate provision of essential items. Requirements of most vulnerable groups are measured mainly here.
	8. Initial Damage and Needs Assessment	In order to compensate and recover, the experts in the area conducts review and determines the damages occurred and the required assistance to recover. Expertise in that area to examine the damage percentages and the required resources.
Recovery Stage	9. Provision of Early Recovery Assistance	Includes the assistance provided in the means of monetary and the knowledge and guidance is considered here. Generally NGOs and volunteers assist government in this aspect.

	10. Temporary accommodation and repair	Until the houses and buildings are restored, providing an impermanent shelter for the affedted community is considered here.
	11. Rebuilding Houses and Buildings	Community housing as well as community buildings such as temples and hospitals, when impacted over disaster and got damaged the time, assistance required to rebuild is measured here. To reinstate people in to the community the government and the relevant local authority contribution also considered.
	12. Restoration of Infrastructural Services	Potable water availability, electricity availability for daily usage are considered here. These are essential for the day to day work recovery of the community. The ability and the capacity to restore in quick and a speedy manner measured the effectiveness of the task.
	13. Re-establishment of Sustainable Livelihoods	Lifestyle sustaining involves economic, human and physical recovery

Time, Mode, Reliability and Accuracy were the erected attributes for early warning, where time is the preliminary criteria whereas other three evaluate the quality of the warning received. Information availability was made tangible by with use of awareness on the knowledge on geological, economical, physical, health and historical data.

Community Based Organizations (CBOs), community leader and guidance were the attributes defined for leadership and coordination.

Water, electricity and accessibility were the three attributes defined for restoration of infrastructural services. Type of disaster, flood was a major criterion and selecting such. For facts evacuation and search and rescue, attributes named necessity and requirement to evacuate were defined respectively and then the following up attributes of time, assistance and involvement evaluate the qualitative fact fulfilment.

Then a question per each attribute was erected. Questions, either generates a quantitative value (Number of days, which was later normalized using a base mark) or a qualitative answer, if the question is a polar question (answered as yes or no).

Based on the above structure two surveys were prepared. Annex 1 and 2 indicates the, community and institutional questionnaire surveys. By using these two questionnaires three case studies of the research were conducted. Simple sampling method was used in collecting the responses for the questionnaire. Where it was obtained more than 30

surveys from each of the case study survey area. In the data collection section of the thesis the data and the sample status are described.

3.1.2 Human – Institutional Behaviour Framework

The Human – Institutional behaviour framework is developed by firstly monitoring and reviewing the cultural behaviour of Sri Lanka.

To understand the cultural behaviour of Sri Lanka, Hofstede insights were used. Hofstede insights compromised six dimensions, Power distance, Individualism, Masculinity, Uncertainty avoidance, Long term orientation, and Indulgence. There is currently no value for Indulgence for Sri Lanka. Hence other five values of Sri Lanka were illustrated and analyse by comparing against three other nations. India, Japan, and Indonesia (Myanmar and Maldives data for the Hofstede index aren't available. Hence regional countries with frequent hazard profiles were used.).

The following Figure 13 is a comparison of values of Sri Lankan culture in five dimensions when compared to Indonesia, India and Japan. [14], [36]
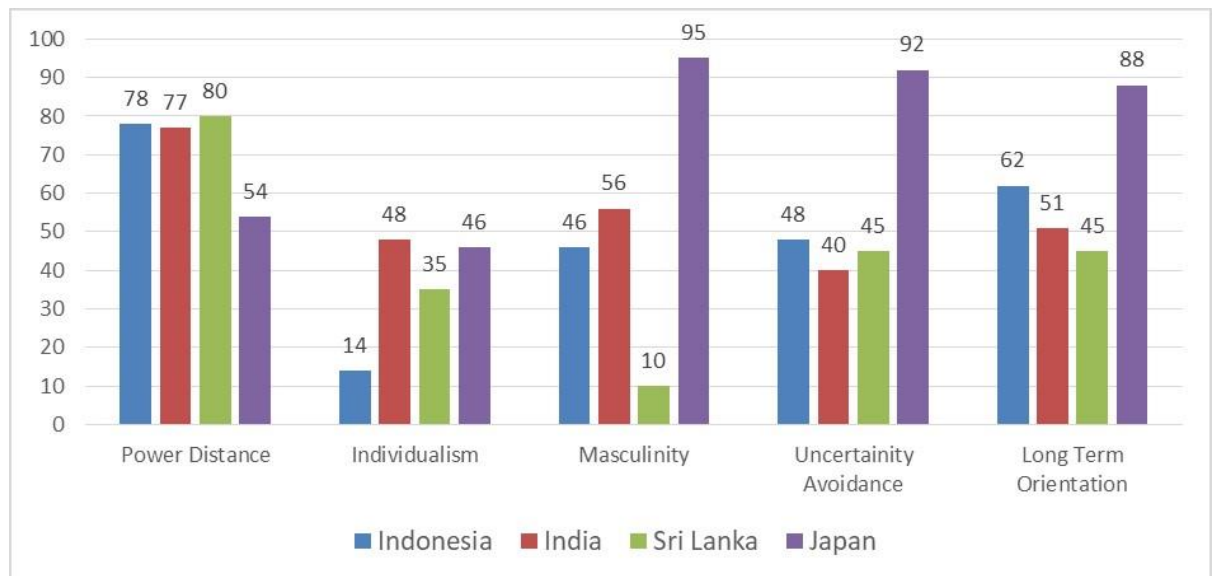
Figure 13: Hofstede Insights of Sri Lanka when compared to Indonesia, India and Japan [10]

The Y axis of the figure illustrates the country wise property as per the Hofstede insights. As per figure Sri Lanka has a higher power distance (80) which indicates a structured hierarchical society which has distinct social norms for each social strata. Hence, usually the power is centralized and it is expected to be direct the lower levels on how and what to do in all aspects. During the case studies it is observed how the communities perceived the managing recovery phase of the disasters (floods) as a responsibility of the government, where they expect the government to provide assistance to build back and recover in the long term.

Collectivist social behaviour of the community is indicated by a low score of 35, in the individualism dimension. This indicates the behaviour of everyone taking care of each other in the community. Then again the very low score in masculinity indicates a feminine society (Masculine culture is focused on values such as money, success and competition (for dominance and power) whereas feminine society is focused on being supportive, caring and leadership oriented.[14]

With a score of 45 Sri Lanka does not indicate a strong preference in the uncertainty avoidance dimension. Which means that the drive for long term oriented decision making and work is low.

In overall these dimensions indicate the strong connectivity between people and community where they intend to be a highly hierarchical collectivist society. This behaviour defines the gap of which external organizations commencing and operating.

Sri Lanka has a culture of collectivism, hence, inter and intra links of individuals, plays a vital role in any community based activity. As mentioned above comparatively a low score in masculinity (10 out of 100, figure) indicates the feminine characteristics of the society of Sri Lanka. A feminine society has dominant values such as caring for others and quality of life is appreciated in development.[42]

The pinnacle of these interactions are visible when the system (community) is in a disturbance, like disaster. Human – Human (H-H) interactions as well as Human – Institution (H-I) interactions generate a significant impact in disaster management process which can be positive or negative depending upon the context it works on. One critical observation which can be made is that during recent floods voluntary groups were formed using H-H interactions whom extend a helping hand to their fellow community.   In Sri Lankan context there are two parts to these interactions. Organizations formed within the affected community and organizations formed external to affected community. In this research work the external elements were identified as the institutions, people or organizations which are not part of the system in its undisturbed state and involved in the system when it's disturbed, where the system is the flood affecting community. These external elements can be temporary or long term established institutions from an outside system.

As Hofstede insights highlight the collectivistic society is one parameter that naturally leads Sri Lankans to assist their fellow community in case of any emergency. Therefore, every time a disaster hits, during the emergency management phase community naturally depends on each other to overcome their difficulties. Also on contrast during the expecting government to intervene during the disaster recovery phase. It is essential to check whether this nature captured in the policy making and enough assistance is provided. Also assessing the efficiency of this mechanism is also investigated during this research.

It is clear that all of the policies and the procedures for disaster management are defined at national level and in the decision-making level as discussed in the literature chapter. There are other elements in the disaster management mechanism such as

voluntary organizations and external organizations. The monitoring and level of space given for these organizations are a gap generated from this review. Identifying the ground level operational effectiveness of these policies with all the stakeholders including external organizations is what comprehensively evaluated from the research.

Shehara et al., 2019 conducted a research using Social Network Analysis theory identified the stakeholder behaviour of Disaster Management (Figure 14).
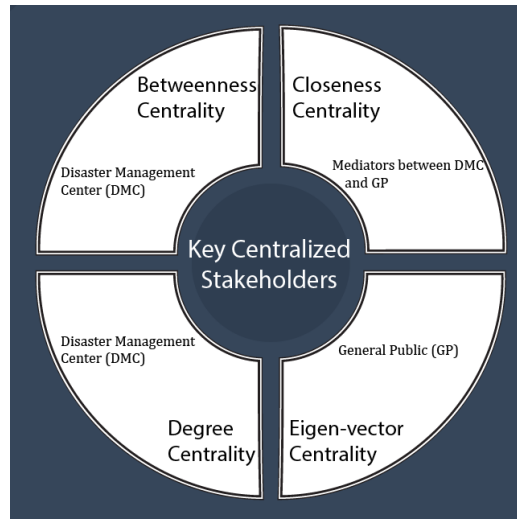
Figure 14: Key Centralized Stakeholders [11]

Furthermore, overall policies and institutional structures indicates the centralized, umbrella behaviour of the Disaster Management Mechanism [43]. The affected community urge for government to do the necessary and required work in disaster mitigation and recovery comes as an output of this mechanism.

In this context with policies and the behavior of the culture and society, it is now looked at how external organizations function in the practical scenario. Following are some key external organizations function in the grass root level in Disaster Management mechanism. One of the outputs observed from the cultural behaviors categorized about Sri Lanka is the "Shramadana". [44] The "Shramadana" is a cultural social activity where people freely contribute the man power for a public purpose. "Sarvodaya" is an organization where this concept of "Shramadana" was structured and institutionalized for better use by Dr. A.T. Ariyaratne as a "Sarvodaya Shramadana" Movement of Sri Lanka. He conducted the first "shramadana" work camp in 1958. As of today "Sarvodaya" is the largest non-governmental, locally founded organization in Sri Lanka. National and international donations, as well as partnership of the organization, are invested in three avenues. Growth and Development, Well trained workforce and emergency relief. [45] Next to these well-established organizations are the organizations that started from the youth generation of Sri Lanka.

Next to these well-established organizations are the organizations that started from the youth generation of Sri Lanka.

International Movement for Community Development (IMCD) is one organization of such, where locally founded and now expanded internationally as well. IMCD works as a social service organization which is formed from alliance of youth. The organization as of today worked with 1200 volunteers, conducted 85 events and has direct beneficiaries of over 74,000. This work was all carried with the collaborations from over 74.000 donors. External organizations do involve corporate sector as well. [46]

There are number of corporate business giants involved in the disaster management. [47], [48] Mass media operators, network providers and apparel manufactures who contribute as a corporate social responsibility. Mass media tend to launch relief aid programs. It is observed in Sri Lanka how community tend to contribute in any possible level for these relief aid programs. Other than to these relief aids the involvement from the corporate sector do involve in risk reduction activities as well. Dialog is one organization as such, where they contribute with research activities. Dialog is one of leading mobile network providers in Sri Lanka. When it comes to DRR activities, one of the community investments from Dialog mobile is the DEWN app. [49] The Disaster Management Center (DMC) together with Dialog launched the Disaster Emergency Warning Network (DEWN). It is the first mobile based disaster alert mechanism of Sri Lanka. It is an ongoing collaborative development with University of Moratuwa. [43]

Other part of these external organizations are the international donor agencies such as Asian Development Bank (ADB), International Monitory fund and World Bank. Furthermore international Red Cross also function in the grass root level addressing the needs of the community. Their contribution is varies from monetary support, expertise support and aids support. That gives an overall view on external organizations' operation in Sri Lanka, how they have evolved and major areas the external organizations involved in. [50]

With the above context on institutions and people related to the disaster management of Sri Lanka following, Figure 15 conceptual framework was developed.
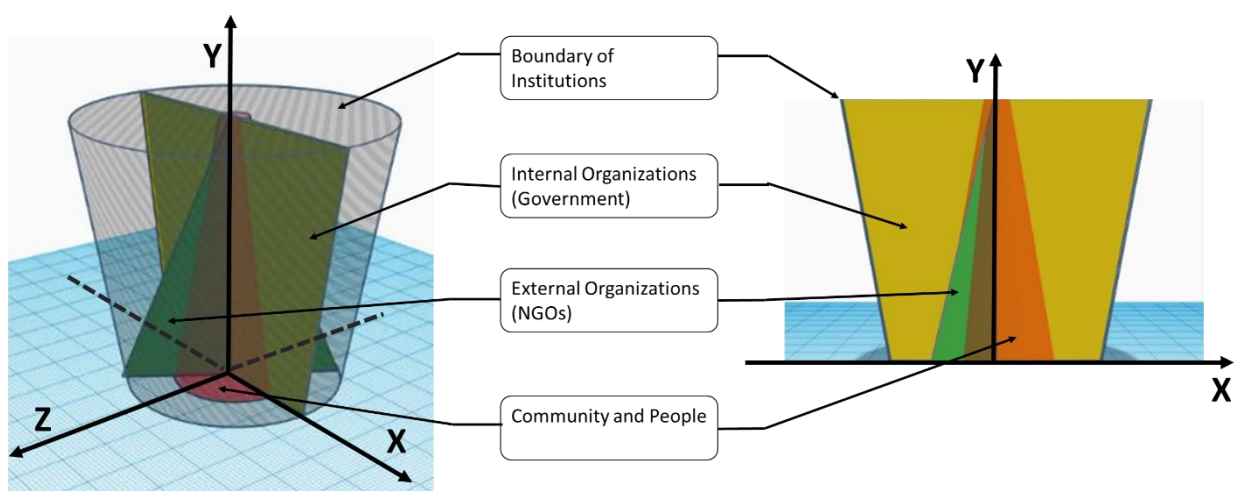
Figure 15: People and Institutional Behavior and Relations

In the figure, X axis indicates the level of interactions, X-Z area ratio indicates the human institutional power delegation (in the top higher institutional area and lower human area shows minimum power delegation), Y axis indicates the level of influence/power and the red color cone indicates people whereas the outer transparent cone indicates boundary of Institutions. The slices (Green, Yellow) indicates organizations, Green – community based organizations, Yellow - Government and governmental organizations. The width of a slice defines the level of interactions with the people from that level. As discussed in the results the illustration stage the nature of behavior in external and government organizations.

Government do have the highest level of interactions and influence from the people up the hierarchy, whereas for community driven organizations the highest level of contribution comes from the bottom part of the people hierarchy. If we take a community based voluntarily group like IMCD, they do have the highest level of interactions with the grass root level. Whereas their interactions with the decision making bodies is minimum. Same time people who lays in the higher level of influence gets decreased along the Y axis.

Likewise the diagram can be used to understand the level of networking and the nature of coordination required among institutions, and institution – human (HI and II).

3.1.3   Map of Gaps in Disaster Management Process

This framework is developed using the data collected from the Matara, Sri Lanka case study. The framework is an example for a map of gaps which can be prepared to identify where and whom to address a gap in a system.

To understand and to be clear on the framework a context understanding on the data is needed. Further comprehensive details from the case study are provided in the next chapter.

There were number of significant barriers identified from the results of the research work conducted at Matara, Sri Lanka, which avert the area from accomplishing acceptable level of livelihood restoration and capacity in the infrastructure even 15 years after the 2004 Tsunami disaster event (Research work was conducted by keeping the 2004 Tsunami as the study object). A major gap was the absence of experience and use of up-to-date technology in disaster management. A missing link was also identified in the administrative process and the indigenous knowledge. One example of such is disregarding the indigenous knowledge on EW mechanisms by monitoring the behavior patterns of animals.

The community was observed to be having lower interest and enthusiasm to actively partake in disaster drills and training programs, which illustrated number of major drawbacks in the evacuation planning. Another barrier in regard to the evacuation planning was identified in a recent research work that it was observed specific planning for people with special needs, pregnant mothers and children is missing [51]. The gap of this missing planning for vulnerable groups creates these groups much vulnerable in disaster events. Also there were number of gaps identified in previous research work related to the early warning mechanisms of Sri Lanka [51]. These identified gaps and barriers should also be proactively addressed in order to enable an effective disaster management mechanism.

Knowledge on income methods, and the critical infrastructure maintenance and locations was lacking among the residents in the area. The development of critical buildings, which can be identified as evacuation centers found to be developed disregarding the building codes in low land areas. The capacities and facilities of the available evacuation centers to be found insufficient. Also the readily available early warning towers are found to be having a range not sufficient for the entire community.

In the means of policy making and governing of the disaster management in the grass root level there are a number of gaps identified from the research work especially for Disaster Risk Reduction activities. There is a lack of policy formation and a defined process in coordinating and facilitating external organizations to the DRR process. This has led to an unsystematic provision backing from various organizations. One example for such is the coordination of the media-driven provisions with the local government processes and systems. The reporting process for compensation and recovery activities, in the aftermath of the previous disaster had taken a long time, making life even tougher for the disaster victims from community. Community has failed to fulfil the disaster recovery stage. It was identified that the processes, systems and policies do not facilitate community empowerment is the reason behind the lack of empowerment and the failure behind the recovery stage.

There are a number of stakeholders (Such as Local Authorities, District Secretariat, NCDM, Community, Media and Meteorology Department) involved in disaster events, who has direct and indirect influence over addressing such barriers identified. Also it was noted that these barriers do have interdependencies. Following map of gaps was prepared to illustrate this phenomenon in a systematic manner.

When analyzing these barriers, four major features can be identified.

   a. Not all barriers are tangible

   b. There is a reappearance of the same gap in various context

   c. The main accountable authority or stakeholder of barriers can vary

   d. Some barriers are a result of cascading of another barrier

Figure 16 shows the processed barrier network. Stakeholders such as Community, Media, NCDM, Local Government, DMC and Department of Meteorology (MET) were the recognized elements/institutions that have main links with the barriers identified from the research work. It exemplifies the cascading nature of every barrier and how each of the intuitions, organization linked with the barriers. It can be used to detect the stakeholders in order to discourse the barriers. The network diagram can be used in policy formation and reactively making measurements for decision making.

A gap prioritizing and clustering or ranking can be conducted using this network diagram methodology.
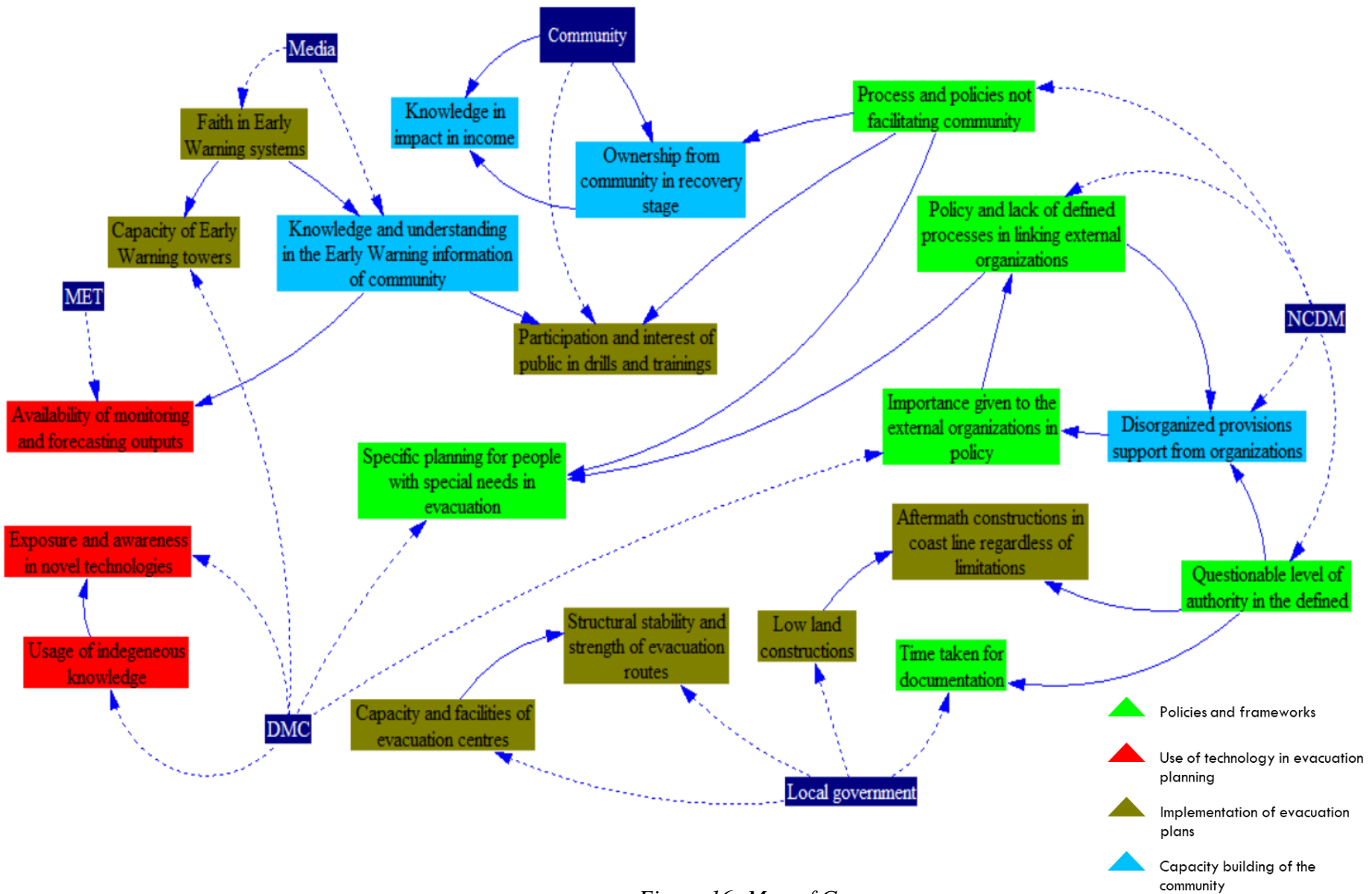
Figure 16: Map of Gaps

3.1.4 Institutional Ranking System

This framework was developed with the data collected mainly from the institutional survey conducted and the literature survey. There were policies and institutions identified from above mechanisms. These policies and institutions are formed and empowered to carry out different tasks and responsibilities for disaster risk management.

The identified institutions were firstly categorized under planning for disaster risk, disaster risk monitoring and disaster treatment as illustrated in the tables. The category titles are compromised from risk management process literature available. Planning for disaster risk involves the establishment of risk context (disaster management policy planning), risk identification (disaster and hazard mapping), risk pre-treatment (disaster risk reduction) activities. The institutions listed under that category are empowered and established institutions in each country to carry out and conduct such work. Disaster risk monitoring activities involve the early warning related institutions of each country. Similarly the disaster treatment related institutions are whom responsible and empowered to carry out emergency response and recovery of a disaster.

This categorization had limitations in differentiating the institutions and identifying the priorities. Hence a framework was developed to evaluate the correlations.

There are mainly two parts of relations analyzed and focused on to understand the behavior of institutions in a disaster management mechanism. Given that disaster management mechanisms are compromised with institutions and people, the two parts of relationships are inter institutional (I-I) relations and human – institutional (H-I) relations as illustrated in the table 4.

Table 4: Institutional relations

Institutional relations	
Institutional - Institutional relations (I-I)	Institutional - Human relations (I-H)

Under each section there are criteria's formed to access the level of the correlation. Once an institution is evaluated under all the criteria's institution can be mapped to compare and cluster. The evaluation framework does not score and evaluate the institutions in most important to least important but cluster the institutions according to the levels of interactions they have.

There are five criteria's proposed in identifying the "I - I" correlations as illustrated in the table 5.

Table 5: I –I Criteria

Criteria No.	Criteria	Response
1.1	Interaction requirement with organizations higher in the power rank	Positive/Negative
1.2	Interaction requirement with organizations lower in the power rank	Positive/Negative
1.3	Interaction requirement with internal organizations in DMM	Positive/Negative
1.4	Interaction requirement with external organizations in DMM	Positive/Negative
1.5	Number of total interactive organizations	Cumulative Number

Power rank is the organizational hierarchy of the country and disaster management mechanisms. There are organizational charts available in Sri Lanka, Myanmar and Maldives which can be used in this criteria [52]. Internal and external institutions are defined as according to the system of disaster management mechanism. Whereas institutions which aren't part of the system during the undisturbed stage of the system are external institutions and institutions which are in the system during the undisturbed stage are internal institutions.

In policy definitions there are provisions made to create the coordination among institutions. Institutions do need to coordinate with other organizations who are having higher authority level, to take the guidelines and direct orders, and pass them as actions or messages to the fellow institutions. These behaviors are evaluated in the criteria 1.1 and 1.2.

In system (community and disaster management) the provisions are provided on mainly on interactions among the internal institutions. Hence the approaches taken by institutions in interacting with institutions internal and external are different. This behavior is evaluated in the criteria 1.3 and 1.4.

Also in the network the total points in the loop are defined the communication criticality of an institution. This is measured in the criteria 1.5.

Criteria 1.1, 1.2, 1.3, and 1.4 has a direct one zero answer. The positive answer gains 1 point and negative answer gains 0 point. There are in middle (fractional) points for those four criteria's.

Whereas in the criteria 1.5 gains fractional point. Maximum gaining is 1 and minimum is 0. The calculation of this point is based on comparison of institutions. The institution with most number of interactive organizations get the highest point and the institution with the least number of interactive organizations gets minimum point. Other organizations gets in between points as proportional to the two benchmarks (The highest and the lowest).

There are four criteria's proposed in identifying the "I - H" correlations as illustrated in Table.

Table 6: I – H Criteria

Criteria No.	Criteria	Response
2.1	Top most interaction point in people hierarchy	1-10
2.2	Bottom most interaction point in people hierarchy	1-10
2.3	Percentage number of people directly interacts with	Percentage
2.4	Percentage number of people indirectly interacts with	Percentage

People hierarchy is the pillar of peoples as mentioned in the literature: Lessons Learned from Interventions of External Organizations In Disaster Management: Case Study of Floods in Kalutara, Sri Lanka [46]. The pillar is of a cone as illustrated in the Figure 17. The power of people is varying along the vertical axis.
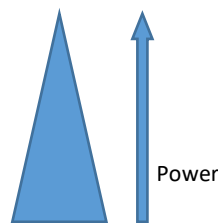
Figure 17: People hierarchy

Direct involvement defined here is the people who can directly communicate with the institution. This includes the people who are working to the institution as well. The people who involves in direct discussions with the institution, people who have veto power over the institution, people who receives communications (messages, orders, guiding etc.) directly from the institution and people who directly send communications (messages, updates, etc.) to the institutions compromised the people who directly interacts with institution.

Indirect involvement is people who has impacts on actions of the institution yet do not communicate directly with the institution. These people gets the benefit out of the actions yet has minimum capability in defining the actions of the institution.

Institutions are governed by people who are in different layers of people hierarchy for different institutions. This behavior of institutions and people are measured in the criteria 2.1 and 2.2. The beneficial party of the institutional activities are the people of the community. Yet the way of beneficial is completely depend on the institutional activity nature decisions. That is measured in the criteria 2.3 and 2.4.

Criteria 2.1 and 2.2 has a combined point range from 0 to 2, including fractions. The difference of criteria 2.1 and 2.2 in compared to the total people hierarchy defines the amount of points gained by an institution. For an example if an institution has the top most interaction point as the top most position of the people hierarchy and the bottom most point as the bottom point of the people hierarchy then the institution has a 100% range hence gains total points, two.

In criteria 2.3 and 2.4 the percentage is calculated as a portion of the total population of the country. Each criteria has a point range from 1 to 0 including fractions. 100% equals to 1 and 0% equals to 0.

With this framework, institutions from Sri Lanka, Myanmar and Maldives were rated and mapped. The results are presented in the next chapter.

4 DATA COLLECTION

Data collection was conducted from three case studies in following manner.

- Myanmar: 4th to 7th February 2019 at Pathein District, Ngwe Saung Township, Ayyerwaddy region and at Nay Pyi Taw.

- Sri Lanka: 11th March 2019 at Matara, Dikwella Division (Wattegama South and Dodampahala East Divisions)

- Maldives: 28th to 30th July 2019 at Maamigili and Male

A comprehensive presentation of the data collection methodology and a qualitative results are presented in following three sections.

4.1 Myanmar survey
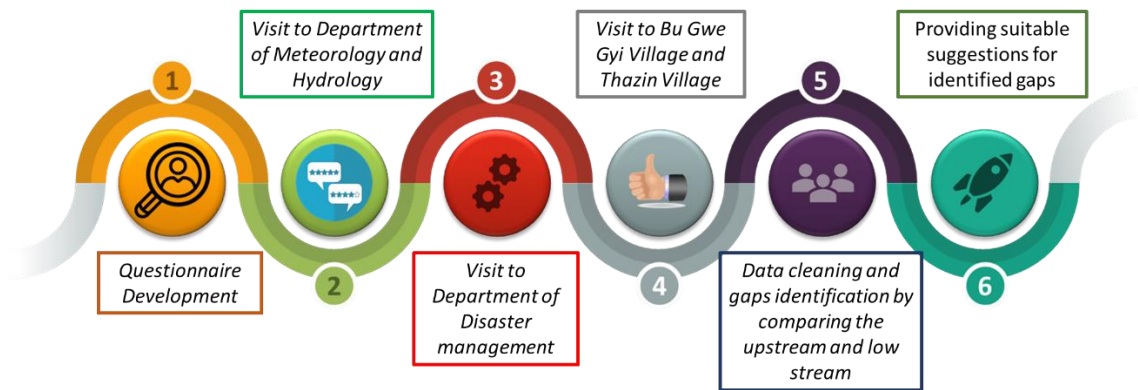
Figure 18: Myanmar Survey flow of events

The Myanmar survey was conducted with the collaboration from University of Yangon from Myanmar. From Sri Lanka team consisted with researchers from the University of Moratuwa and the University of Peradeniya. As illustrated in Figure 18 the survey had two parts.

Firstly there were visits to the institutions, Department of Meteorology and Hydrology and to the Department of Disaster Management. At institutions there were discussions as well as questionnaire (Annex one, institutional questionnaire) carried out. The team conducted the survey is presented in the Figure 19.

Figure 19: Survey team from Sri Lanka and Myanmar

4.1.1 Department of Meteorology and Hydrology (DMH)

The department consists of three sections.

1) Seismology Section (National Tsunami Warning Centre): In the centre, the survey was carried out with the coordination from Dr. Yin Myo Min Htwe, the Assistant Director of the Seismological Section. Observations on the mechanisms and plans used for early warning of tsunamis and earthquakes in Myanmar were specially focused at the centre. Also gained further insight into the organization and its activities using a prepared questionnaire.

2) Hydrology Section: The Head of the Hydrology Section in the DMH coordinated the survey and observations on the procedures of the Hydrology Section, especially in terms of activities regarding floods were observed.

3) Meteorology Section: Dr. Tin Mar Htay, the Assistant Director of the DMH coordinated the study where the monitoring process and technology used in the Meteorology Section were thoroughly viewed.

In the Department of Meteorology and Hydrology- (National Tsunami Warning Centre) - Seismological Section's main role was identified as issuing warnings for Tsunamis and Earthquakes. The section implemented in the year 2004. Seismology

section was equipped with 23 staff members working on the process of monitoring the seismic activities and issuing of early warnings. Specialists mainly in the fields of geology, geophysics and seismology are directly involved with the section.

Majorly coordination with stake holders such as General Administration Department (GAD), Department of Disaster Management (DDM), Red Cross Society, Ministry of Health and Sport, NGOs, TV and Radio Channels includes the section's tasks. For that there are two standard operating systems (SOPs) used for inland and offshore available from the department and in use. In the coordination plan, the section receives Tsunami and EQ information and disseminate the warnings to the above mentioned parties. In the case of evacuation, DMH does not play any major role since it is a sole duty of Department of Disaster Management (DDM) along with the leadership of national disaster management committee and other 12 working committees.

In terms of the reporting mechanism, the department keep the records to themselves after a disaster and currently it was not observed any measures for evaluation or review the effectiveness of the working process.

There were number of gaps observed and identified solutions from the visit as well. Because of the less productiveness and efficiency in monitoring the seismic activities, they have managed to advance the technology from analog stations to digital stations. After implementing four digital stations they have been overcome the problems in long process time and accuracy of the monitoring process. Moreover, although there are 30 seismic stations, most of them are not working and the plan is to increase the number of seismic stations with digital technology.

Also it was identified that according to the past experience it could have been much effective to use different languages for different regions. It was suggested to increase the effectiveness of the process of repairing the seismic stations if a breakdown happens. According to the current situation, the process has to be handled by the DMH head office which results in spending unnecessary time for repair.

The department is well equipped with the technology. One identical fact is the use new software like Siescomp3 and Antelope, a collection of programs for data analysis.

Recently department cooperated with community based organizations to cover a series of activities at the community level aimed at bringing about desired improvement in the social well-being of vulnerable individuals, groups, organizations related to disaster management in Myanmar.

Department plans to enhance the performance of the organization by installing sirens for Tsunami early warnings which are currently not installed in Myanmar. Furthermore, there are proposals to collaborate with China Geological Survey Bureau (CGSB). Since the research and development in disaster risk reduction is not substantial, it is planned to initiate more research with university students and also with government officers to find and explore new technology.

4.1.2 Department of Disaster Management (DDM)

The visit was organized as a round table discussion with Deputy Director General, Li Than Htut Swe and four other Directors of the Department of Disaster Management.

Organizational purpose and activities in disaster management, capacity building and raising awareness as well as coordination for emergency response, rehabilitation and reconstruction were the topic areas discussed initially. Then the discussion was followed on to identify the gaps in the Disaster Management Mechanism. Emergency Operations Centre observation was also carried out as an introduction to identify the roles.

The DDM was established in 2005 after the catastrophic Indian Ocean Tsunami in 2004. Now the DDM is equipped and scoped in to managing and engaging all types of disasters impacting in Myanmar. Further capacity building and improvements for a better coordination system are developing inside the department as well as outside from department guidance. Vision to establish more collaboration in response and more response capability for vulnerable communities drives the department to enhance the effectiveness of their role by mitigating disasters.

DDM plays the role of capacity building and awareness raising, coordination for emergency response, rehabilitation and reconstruction. For example, they have a disaster management training centre in terms of capacity building sector. They perform drills and exercises for the vulnerable communities in terms of awareness raising. Depending on the severity of the disaster, there are 5 emergency status levels.

DDM coordinate with General Administration Department (GAD), DMH, Myanmar Red Cross Society (MRCS), Public Health, all TV channels, INGOs and NGOs and other responsible government ministries.

The DDM and GAD coordination in disaster management in Myanmar is done under 5 administrative levels of the general administration department (GAD) namely, village level, Township level, District level, Regional level and National level.

If a particular disaster strikes indicating a higher severity, then the response level will be advanced to the suitable upper level to involve and engage in responding to the disaster. In each level there are 12 working committees, namely;

1. Disaster management work committee

2. International relations work committee

3. Financing and financial management work committee

4. Search and rescue work committee

5. News and information work committee

6. Rehabilitation and reconstruction work committee

7. Health care work committee

8. Initial need assessment/ damage and lost verification and need identification

9. Livelihood restoration

10. Environmental conservation

11. Security work committee

12. Logistics work committee

The organizational structure of the disaster management bodies of Myanmar consists from these 12 working committees. The DDM works under the national disaster management committee perform the duties in disaster management work committee. And also, according to the director general manager's note, they also establish the coordination between these 12 work committees.

During an evacuation, the suggestions and the message to evacuate will be taken by the DDM along with the GADs. The reports from the DMH and the other international organizations will be compared and warnings will be issued accordingly and occasionally. The DDM reports to the national disaster management committee which lies in the upstream level of the organization structure.

In future, they plan to initiate Disaster Alert Notification (DAN) software as a mobile app. This app is planning to provide information on early warnings and the emergency information and guidelines. These initiatives will reinforce the disaster preparedness of the vulnerable communities in Myanmar.

4.1.3 Community Survey (Bu Gwe Gyi Village and Thazin Village)

The community survey was conducted in two communities and each community the survey had two parts. The survey started with a group discussion with the community leaders, elders and the research team. The overall village level structure, history, disaster response experiences were discussed. Following that the individual questionnaire was conducted. The community villagers were individually interviewed and grass root level disaster management was evaluated.

From received and collected responses majority are from men. Above 50% of the responses are 41-50 years aged farmers. A comprehensive respondent profile is provided in the end of the chapter. Majority of the respondents identified "Storms and heavy rains" as the most severe coastal hazard of the community.

Under the disaster risk reduction and preparedness for the early warning, generally identified systems available for early warning are from Radio and TV whereas Door to Door and loud speakers being the historically used systems. The loud speakers were identified as the warning method that communities are most likely to respond. Then again the reluctance to leave property and agricultural lands was identified as the most likely reason for families to stay in the households even after receiving the warning.

The lead time between the disaster and the point of early warning stayed 2-3 hours for Tsunami and for coastal hazards of storms it was two days at most. This lead time was enough for villagers to reach to a safe location, monastery in both villages. The entire village and community was aware about the safe location as monastery and they identified it as the highest place of the village while understanding the safest and quickest route to the safe location from the household.

It is important to highlight about the built-up of the households in both villages. Most of the houses were built from wood about a feet above the ground level using supports. Number of positive aspects were identified about these structures, including the air circulation, heat transferring, safety from ground animals etc.

Community had an understanding on impact on farms and other means of the community incomes during a disaster. Most of them told that their jobs will be disturbed when a disaster strikes. For example, in the village there were lot of coconut farmers and during the disasters the trees used to fall and they might be helpless. And also they had an understanding on the health related of hazards, especially floods.

In the year 2011 one village had a 3 day training program to train the community of Tsunami evacuation and drills. Other than that none training or drills were carried out. Also there was hardly any development activity carried out in the coastal area to reduce disaster risk. Yet recently electricity was introduced to the area.

During a disaster, immediate actions were taken from villagers itself, the village administration committee. Other than that GAD, Fire brigade, municipalities helps during a disaster as humanitarian support. But it was clearly highlighted that villagers themselves take care of the community. Other than warning dissemination and information delivering people failed to identify any other involvement from local governance structure during a hazard most of the time. The basic need acquiring was rated as the highest emergency need of the people.

Community do not display a mechanism or a process to estimate damages after a coastal hazard. The general procedure was again that villagers by themselves help each other to build back from damages. But there are some non-government organizations like youth associations to help people in a disastrous situation and post disaster period.

As soon as the flood dries down people has access to drinking water since community utilize a well to gather water. Also when it comes to electricity, in Bu Gwe Gi new hotels and resorts have been constructed and electricity have been given because of the tourism industry. Since, lines were added very recently(1 month), people did not had a clear experience on how long it take to restore the electricity and other infrastructure. For the other village (Thazin Village), the electricity is not yet available. Hence data on the restoration of infrastructure in terms of electricity was not available at the time of the survey.

4.2 Matara Survey

The objective of the field survey was to evaluate the coastal evacuation, coastal disaster resilience and understanding the Disaster Management Mechanism of Sri Lanka – Matara with the same objective carried out in Myanmar Field Survey. There the data was collected from the upstream of the Disaster Management Mechanism as well as from the downstream. During Matara Survey, focused on collecting data from the downstream. The eventual outcome was to identify gaps and then to compare the Disaster Management Mechanisms to identify the improvements and generate suggestions.

The survey was conducted by researchers from University of Moratuwa and University of Peradeniya as illustrated in the Figure 20. The survey had a methodology of two steps. First one was Grama Niladhari (GN) office discussion with GN and community

Figure 20: Sri Lanka survey team at Matara

leaders. The objective was to understand the overall picture of village level Disaster Management Mechanism. Further, the GN along with the officials in the office introduced community leaders. Then the groups separately visited houses in the village to collect data. Secondly the individual community survey using the community survey questionnaire to evaluate the disaster management mechanism in grass root level.

Same methodology was carried out in two community areas. In Matara district, the Dickwella Divisional secretariat division was selected to conduct the survey where 2004 Tsunami had a comparatively massive destruction. At Dikwella DS division out of 48 GN divisions, Dodampahala East and Wattegama South Grama Niladhari divisions were selected with the assistance of Dickwella Divisional Secretary.

Tsunami early warning and evacuation activities were started to implement after the 2004 Tsunami disaster. It was observed that from administrative level as well as from the community level, pre-preparedness activities were implemented thereafter. Yet after 11 years of Tsunami disaster, in 2015, the direct administrative job role allocated to the GN on Tsunami duties had been removed.

Early after Tsunami, number of trainings and drills were carried out for the preparation of community. It was observed that the frequency of these drills are about two per year.

From the administrative process, a direct link with all the community based activities are observed where GN being the authorized person. Community based organizations were performed to keep the community empowered and own the preparedness, the administrative keep tracking and monitor the activities where the processes are in place such that they have the proper guidance.

Furthermore, it was overserved that the unsettled nature of the community due to the cascading impacts of the Tsunami which we discuss further in the following section. According to the officials of DS/ Dickwella, flooding is the most vigilant in terms of the risk and preparedness. Time of the waves hit on coastal area can be measured technically and measuring that in the flood is difficult. Therefore, impact of flood is unpredictable.

a) Stakeholder and Process Management

Even though there is a well-defined hierarchical system, the practical approach is much disturbed. It compromised the involvement of other undefined parties such as Non-governmental organizations, voluntarily organizations etc. who acts independently and most of the time involved in without the consent from the authorized personal. There is a less coordination among pre-preparedness mechanism and post-disaster mechanism. For an exemplification, plan for pre-preparedness is set by divisional secretariat and under authority of higher divisions and post-disaster mechanism is complex, because that complies with military servants, volunteers, other civil officers out of the DS and politician. Many of their activities are not align with pre plan and therefore, pre-preparedness mechanism is an utter failure due to lack of coordination.

b) Resettlement

The community who was originally located inside Matara who have the main income method as fisheries are resettled at the Dodampahala Tsunami village in which the resettled land is much far from the sea and generates issues in continuing the income method previously they had. (Fishing) Many houses granted by the government to Tsunami victims in the area are not properly built in terms of physical conditions and seemed to be unplanned. Moreover, none of houses were handed over to the people with proper documents such as deed, authorization letters etc. and ownership, therefore, building ownership has become a serious issue. However, documents have been preparing by the authority and still the process is unsatisfactory. For instance, in Wattegama/south, 56 houses are available in the Tsunami housing scheme and only 26 units of them reported to be legal in terms of prevailing documents to prove ownership. This issue is common for Dodampahala village as well. There are two tsunami villages in the Dodampahala: One is Minikirulawatta which has 100 houses; the second is Arahena which has 50 houses. Without proper documents (deeds, water and electricity bills) inhabitants face real difficulties to get their children to be selected for schools according to the given criteria. Even though, many of tsunami villages were built in

comparatively with higher elevation, distance from the sea has badly influenced to their livelihood activities. For instance, there are several temporary job opportunities among boatmen and fisheries community and they cannot find individuals for their daily needs quickly as many of settlements are far away from the coastal area. Due to above reasons many tsunami houses have been rented out or sold out by owners during previous five six years. However, selling houses is a problem for them as they don't have proper deeds and all.

c) Vulnerable Constructions

There are several unauthorized and temporary buildings and constructions along the coastal belt in the area. Many of them are encroachments of coastal reservations. These buildings are highly used for tourism. Many of public buildings including hospitals and schools were also located in law lands, except a few, as observed by researcher. This will be a serious risk in a disaster incident as many of children, patients and elders are under threat in hazards.

d) Early warning technology and usage

Sirens located in the towers is the best and effective method among others as many of participants responded. According to them, the noise comes out from the tower warnings makes a psychological fear among inhabitants on a disaster. Hence, people use to prepare suddenly and none of other systems are properly work. Further, with the tower warnings, people in the area getting stuck in roads and safety routers and buildings, because they do not aware about the time duration which waves touch the coast. That system has to be developed. However, strength of the tower warning has to be further improved, because people of Dodampahala cannot properly hear the tower warnings, GN stated. Speakers are less effective in a flood, because people cannot hear the message due to heavy rains. Majorly preferred early waring method for the community was EW tower siren. Also being a very close community door to door was again identified as an efficient method next to the siren.

e) Disaster preparedness drills and trainings

People are not much enthusiastic in participating of drills for evacuation. However, they are sensitive for warnings. According to the officers of DS office, people are now well aware about warning systems and safe routes and places. Only issue is many of them don't concentrate on what their ahead and feel necessity, because they faced only for one tsunami incident. If this happen regularly people will more corporate.

Even after 14 years, a fact revealed from the sample is that the majority (65%) are not happy with their current state when compared with the 2004 state. (Build back better is not achieved for them).

4.3 Maldives Survey

Understanding the Disaster Management Mechanism of Maldives and Identifying the gaps and barriers in the disaster management mechanism were the two objectives followed up in the Maldives survey.

Figure 21: Sri Lanka team at Maldives

As with Myanmar survey there were two aspects of the survey, the community survey and the institutional survey. Maldives national university coordinated the survey from Maldives. Researchers from the University of Moratuwa and the University of Peradeniya from Sri Lanka compromised the research team as illustrated in the Figure 21.

4.3.1 Meteorological Department

The director of the department was the resource person during the survey. The survey initiated at the department with a discussion and then on visits around the activities to understand the involvement of the department in disaster management for Maldives.

Main job and service of the Meteorological department is to monitor and issue early warning. Police, Maldives National Defence Forces, TVM (public media – TV), VOM (public media – Radio), Airport and National Disaster Management Center are key stakeholders of the Meteorology Department. Also the department monitors ocean currents, ocean temperature as a main task given that Maldives as an island country entirely depend on the behavior of sea.

The department exists since 1975 and keeps records of all the data available in an accessible manner. The technology used in the department is up to date as observed in Myanmar and a stand out factor is the use of Mobile app (Monson). Radar system of the department is another highlight given the fact and need of tracking the sea and related aspects.

The department plans to integrate all the monitoring systems to one main system. Such that the existence of data are further accessible and can analyze from one place for efficient usage. In emergency situations other than to the data systemizing the people

preparedness is highly monitored. Where the technical workforce gather within 10 minutes time duration to proceed with emergency situations.

The department carries out activities to enhance the knowledge capacity and risk mitigation capacity development. Awareness sessions are facilitated by the department in schools at different islands. Also island wide drills were organized by the department with the participation of all the stakeholders. And annually community testing is conducted by the department to understand the vulnerable sectors and to understand the hazard maps.

The communication from department towards the grass root level is mainly from the app and also from the community Viber group. This is a new initiative from the department where within 7 months, 14826 people joined to the group where the group is only a one way communication from department to the community. Also it was identified from the department that the most efficient communication modes are social media, mobile app, SMS systems.

The department equipped with an alarm system which alters earth quakes above Richter 5 of magnitude. Any alerts above > 7 of magnitude, there are standard operating procedures in place to follow. The department have a separate land phone communication system which is to be used during an emergency, each land phone dedicated to each organization in emergency response such as, Air Port, EOC, NDMC, TVM, VOM, PTWC, MNDF and Police.

4.3.2 National Disaster Management Authority

In the national disaster management authority the survey was entirely conducted as a round table discussion with the director general of the authority. The overall disaster management mechanism in Maldives was presented and discussed during the survey.

Initial situational studies were started around 1980s. After the Tidal Wave Incident, Suggestions from the workforce to the government of the Maldives were suggested to implement or set up specific institution for Disaster Management. After that, in the president's office a body within them have come up with a set of frameworks and guidelines with an institution to work on as Disaster Management Center. Before 2004, Maldives was a very peaceful country. They haven't faced many natural hazards or and government was not bothered about the disasters until the 2004 Tsunami.

During the initial Period (2004 -2008) after Tsunami, reconstruction and relief operation processes were carried out while DMC and other institutes related to disaster management were established by President of Maldives. These organizations were given the lead to manage the relief and recovery operations during a disaster which also includes integration between different organizations, reconstruction and rehabilitation. After 2005, they stated to work with international partners on resilience of building and the communities to carry out events such as risk assessments and come up with hazard profiles. Around 2007, Maldives had the first disaster risk profile done for 10 key islands with the support of UNDP which is the only recourse done up to

today. Those risk assessments were used for planning and the understanding of what sort of disasters that the Maldives will have a risk of going through. DMC or currently named as NDMA has started to work with organizations such as UNDP, ADPC and Mercy International and have started a program called Community Based Disaster Risk Management (CBDRM) Program. Currently, in 52 islands, they have conducted the initial CBDRM activities. NDMA has reviewed their old process and have come up with the CBDRM version 2.0 with better performance. Now the CBDRM 2.0 has been integrated with the program of island disaster management plan as a tool. Also NDMA has established local disaster management committees and community emergency response teams and have looked into how early warning mechanisms and communication systems can be established and practiced in the islands while simulation exercises are also performed in the islands. CBDRM 2.0 has been started to develop in 2017 and have worked in 4 islands using this newly developed tool during 2018 and 2019. But 50 other islands have been covered through the old version of CBDRM. Due to the rapid changes and developments happening in Maldives, especially in the islands, the CBDRM tool must be revised in a way suitable for the current context and the future trends in the country.

Maldives currently have the Disaster management Act of Maldives since 2015 which have set the entire direction for the government towards disaster management which specify the responsibilities of the government or state and the citizens of Maldives. The existing governance framework is led by the NDMA and the president of Maldives along with the National Steering Committee which is a technical agency. For many reasons the establishment of NDMA was hold by the presidents of Maldives until 2018 December. But with the change of government and the severe flooding occurred in Male, the current president of Maldives has taken steps to establish the NDMA by transforming the DMC into the NDMA. There are lot of stakeholders involved with NDMA and some of them are, National Emergency Responses Forces (NERF), MNDA, Police, public health organizations, Maldivian recurrent. Early Warning mechanism is also guided by the Disaster Management Act of Maldives and it says that NDMA should have a national emergency operation plan in place which also needs to be revised every 5 years' time or periodically basis on disaster conditions that the country is facing. In early 2018, with the support of the World Bank and a Sri Lankan consultant team, the National Emergency Response Plan (NERP) of Maldives was completed and currently NDMA is working with other ministries to identify the major changes that should happen in the system and incorporate them into the National Emergency Response Plan (NERP). NERP document has 2 volumes. Volume 1 is about Legislative Arrangements and institutional arrangements for emergency response in the country and coordination within the country (Chapter 1 on DRR, Chapter 2 on early warning mechanism where different hazards will have specific organizations/ministries responsible for issuing early warnings). Volume 2 is about the analysis of functions before, during and after a hazard.

Different ministries have to come up with their own early warning mechanisms and ways to issue early warning alerts within their ministries while communicating and

coordinating with NDMA. These ministries have to issue early warning alerts, not status alerts. NDMA is the body responsible to issue sautés alerts (level of emergency that the region or the island is at). There are 3 main emergency declaration methods/ procedures in Maldives which is Included in the NERP. First one is the Constitution where the President of Maldives has the right to declare the notice. Second one is the Disaster management Act of Maldives where the President of the National Disaster Management Council (president of the country) declare the notice. Thirdly the Public Health Act where the Director General of Public health with the consultation of the Minister of health declare the notice. There are 4 levels of emergency alerts in NERP as below,

a) White: Ministry of Operation Center and Disaster management authority get together and decide in releasing the alert

b) Yellow: Ministry of Operation Center and Disaster management authority get together and decide in releasing the alert

c) Orange: President and the disaster management Committee are involved in releasing the alert

d) Red: President and the disaster management Committee are involved in releasing the alert

National Disaster Management Plan (NDMP) has not been published yet due to many reasons such as waiting for Sendai Framework and after publishing of Sendai framework waited for National Guidance document from the Sendai Framework. Currently, working with National Development Plan. Therefore, NDMP will be included in the National Development Plan as no need of several documents. But it's a must to have a NDMP in the country according to the law and it has to be reviewed every five years' time and has to be integrated with the National Development Plan (NDP). Usually, MET issues forecasted warning alerts or early warning alerts. NDMA issues situational (advisory) alerts after proper analysis from the data they receive from different stakeholders. NDMA of Maldives have observed the alerting mechanisms of India, Sri Lanka and other South Asian countries to improve their mechanisms. Any technical agency who has the relevant technologies and knowledge can issue their own warning alerts and those have to be coordinated and centralized to the NDMA. Currently Maldivian NDMA is working towards a centralized system/process. NDMA will look into the alerts issued and the ground reality of the situation, and say where the state is right then, in level basis (with color codes).Generally what NDMA does is analyses the different alerts and issue a common alert to local councils but not issuing early warning alerts. Also they issue advisory alerts, where other agencies or organizations can't issue. Local councils will pass the alert message to different island councils. During the 2015 Tsunami threat that they had, the whole network was broken down within 30 minutes. So currently they are working on a satellite network system

as a backup system (plan B) during a hazard which is connected to Indian SAAC satellite system and it is technically assisted by UNDP.

Maldivian government and private institutes face a challenge due to lack of sufficient resources such as, technology for real time data monitoring and management, have to work with secondary information rather than direct information as no resources to come up with own direct information. Coordination between local councils and the general public is really weak, especially in contacting the island council presidents. Local council including the president of the council handle groundwork due to the lack of proper and timely coordination and the difficulty in receiving and sending the information between island councils. There are 4 regional commands given by MNDF under the arm forces act which is also responsible to respond in an emergency crises on their own. They also have their own mechanisms and coordination with the NDMA. There are 7 regional divisions of the police across the country which also actively involved in emergency situations. Maldivian police is better in communication and coordination as police has more stations and man power than MNDF. But MNDF has more resources compare with the Maldivian police. NDMA is also responsible for moving people during an emergency. For 54 islands, which they have completed the disaster management plan, they have a database which mansions all the details about the resources available in each island such as number of trained people available with their details, available resources (such as water drainage pumps and firefighting equipment) and people whom to coordinate. For islands where the planning is not done yet, it's difficult to communicate and coordinate during a disaster. With the response and advises getting from NDMA, island councils can work on their own plans, but they have to inform and coordinate everything to the NDMA. Each council has their own SOP and mechanisms which have coordinated with NDMA. Maldivian councils have 2 acts that they can work on as Local Government Act or Local Decentralization Act which is not specifically about disasters but about all community affairs and the Disaster Management Act that has a sub clause about disaster management in local communities which gives the local councils the authority to establish disaster management committees in islands which gives the leadership to response. NDMA also helps to formulate these disaster management committees while increasing the capacities of island communities. Through decentralization act, the power to execute their plans have been restricted for the 3 city councils that the Maldives have but not for the local councils. The authority in decision making of city councils have been taken off by the state. This makes the state authority to handle all city level minor incidents and hazards as well due to lack of top to bottom flow. Therefore city councils should be given the responsibility to handle city level hazards while NDMA work as a top level authority who coordinate everything. Also when the NDMA gives away the responsibility to local councils, they don't act without providing the resources. But NDMA don't have sufficient resources to provide them with.

Currently, NDMA has taken many national and city level initiatives in DRR activities. One of them are, school programs based on Tsunami which provide the knowledge about natural hazards that the Maldives is more vulnerable into and the proper training

drills are provided to school children. Community based programs can be identified as another initiative of NDMA which provides the awareness and trainings with a certificate for the delegation. With these initiatives the NDMA also faces many challenges as well. The trained people won't retain due to the knowledge and certification received, as they move to different islands and resources for jobs. Therefore difficult to maintain the trained team during an emergency. Therefore, a new mechanism should be introduced and implemented to sustain the trained teams. Resources such as drainage pumps, firefighting equipment should be provided to Island council levels to work their own without waiting for forces. (This has been started to provide during projects conducted in the islands). Incorporating cluster system to divide the NGOs depending on disaster type. NDMA is also working on new innovations such as incorporating GIS into the CBDRM to expand the system as currently they are using drones to draw map and seeking collaborative support from university to get support to expand GIS and real time data management. Also Maldivian NDMA is current working on identification of required research areas to be developed and doing research on this areas such as flooding and its pattern, effects due to sea level rise and climate change, etc. NDMA also looks for long term sustainable partnerships with universities and academia as research partners and industry partners to mitigate the disasters and build up disaster resilient constructions.

4.3.3 Community survey at Maamigili

The community survey was conducted in two steps. First was a meeting with the village council with the objective of identifying the implementation of national level activities and the processes. Second was the individual community survey with the objective of evaluating the overall disaster management mechanism.

Maamigili Island is a relocated community from Madifushi Island which was totally destroyed from Tsunami. Hence it was highlighted that the present island conditions are better and safer.

There were major observations and identifications from the council meeting. Community has its own Viber group (most widely used) to make the community alert on natural hazards. All the council officials are also connected through it. The directives from the national level are also communicated from these groups.

Maamigili Island do not have sirens or Tsunami Warning towers in the island. But there's a one way communication system for emergency Early Warning system. The council stated that there weren't any Tsunami drills conducted in the island. The council is responsible in following Standard Operation Procedures to follow before, during and after natural hazards. Also it was identified that the community has no specific plan to treat people with special needs.

As mentioned the community surveyed are relocated from Madifushi Island after the 2004 Tsunami. Tourism sector, Mosque work and government service are the main occupancies. Madifushi had a high impact from the Tsunami event. The island was not habituated after the event and recently a resort was started to construct.

The Maamigili Island has a sea wall to protect the island. These constructions are a result of the airport development. The island is safe from Tsunami as of today and acts prone to most coastal hazards.

By the time of the Tsunami Madifushi had no early warning system dedicated to island with respect to Tsunami. The TV/ Radio was the only method available at the time. Now at the Maamigili Island the council gets information as well as individuals has direct access to data and updates for disasters.

The income methods at that time were destroyed and completely abounded at Madifushi. With the rehabilitation new income methods were implemented. It was majorly a transfer of work from Madifushi to Maamigili. The community stated that the level of work is better at Maamigili now, when compared to the Madifushi state back in 2004. The relocated people has lands for themselves. As mentioned at the council the land ownership is awarded by the state by considering number of criteria and eligibility.

It was the state contributed to the development of lands and houses. Yet there were business men who acted in responsible manner in after the Tsunami disaster for the betterment of the community. They have provided the community with ways of evacuation (boats), shelter for the time being and also offered number of job opportunities.

Above three surveys were conducted using the evaluation framework described in the 3.1.1 as the questionnaire framework. The data gathered from these surveys were used with the institutional ranking system as well. Results chapter illustrates the data presentation from the institutional ranking system for the three countries and the overall idealization process on the disaster management mechanism in a risk management perspective.

5 RESULTS AND ANALYSIS

5.1 Effectiveness of Disaster Management Mechanisms

Following effectiveness calculation was conducted based on the data collected from the Community Questionnaire survey conducted. (Hence the values obtained were specific for the community area the survey conducted. With the assumption that the results can be more or less general or on average for the country situation the cascading analysis were conducted.)

Three base definitions were used in calculating the effectiveness.

- Scale for all the questions varied from 0 and 1, all binary output was created for the further analysis with elements on principal component analysis.

- A complete Yes is a 1 and a complete No is a 0

- Base time targets were set for the quantitative questions to generate binary output as illustrated in the table 7

Table 7: Base time definitions

#	Question	Base Definition
1	How many days ahead were you notified about the flood?	Considered notifying at least one day before as a 1
4	In days, how accurate was the news you received?	Considered 0 days as a 1
15	If yes, how long did it take to evacuate?	Considered 2 hours as a 1
19	How long did it take to get help?	Considered 2 hours as a 1
24	Provisions you received were, Not enough/ Enough/ Too much	Considered enough and too much as a 1
30	If yes, how long did it take to find one?	Considered 1 days as a 1
31	How long did it take to rebuild any household damages?	Considered 3 weeks as a 1
33	How long did it take to access drinking water without provisions?	Considered 0 days after the flood as a 1
34	How long did it take to get uninterrupted electricity?	Considered 0 days after the flood as a 1

35	How long did it take to use the roads again?	Considered 0 days after the flood as a 1
36	How long did it take to get back to your work/job after the flood?	Considered 0 days after the flood as a 1

Then effectiveness percentage for each attribute was calculated, by the ratio of total responses and total 1s. Fact effectiveness percentage was calculated from the attribute percentages by using the weightage defined for the each attribute as illustrated in the table 8.

Table 8: Attribute Weights for Fact Percentages

Fact	Attribute	Weight
1.Early Warning	Time	1
	Mode	nil
	Reliability	nil
	Accuracy	nil
2.Information Availability	Past data	0.17
	Geological knowledge	0.17
	Geological knowledge	0.17
	Physical structure	0.17
	Economic knowledge	0.17
	Health knowledge	0.17
3.Capacity Building	Activities	nil
	Physical Development	nil
	Exposure	1
4.Evacuation	Necessity	nil
	Time	0.5
	Assistance	0.5

5.Search and Rescue	Requirement	nil
	Involvement	0.5
	Time	0.5
6.Leadership and Coordination	CBOs	0.33
	Community leader	0.33
	Guidance	0.33
7.Provision of Humanitarian Assistance	Involvement	0.5
	Effectiveness	0.5
8.Initial Damage and Needs Assessment	Checking	0.5
	Effectiveness	0.5
9.Provision of Early Recovery Assistance	Financial	0.5
	Knowledge	0.5
10.Temporary accommodation and repair	Requirement	0.5
	Fulfilment	0.5
11.Rebuilding Houses and Buildings	Time	0.5
	Money	0.5
12.Restoration of Infrastructural Services	Water	0.33
	Electricity	0.33
	Accessibility	0.33
13.Re-establishment of Sustainable Livelihoods	Economic	0.33
	Human	0.33
	Physical	0.33

With these base definitions and weightages for each attribute final effectiveness results obtained for three case studies are as follow, Table 9, Table 10 and Table 11.

Table 9: Matara Sri Lanka, Fact Effectiveness

Fact	Percentage
1.Early Warning	40%
2.Information Availability	77%
3. Capacity Building	19%
4.Evacuation	35%
5.Search and Rescue	50%
6.Leadership and Coordination	58%
7.Provision of Humanitarian Assistance	89%
8.Initial Damage and Needs Assessment	62%
9.Provision of Early Recovery Assistance	89%
10.Temporary accommodation and repair	58%
11.Rebuilding Houses and Buildings	54%
12.Restoration of Infrastructural Services	2%
13.Re-establishment of Sustainable Livelihoods	53%

Table 10: Pathein District Myanmar, Fact Effectiveness

Fact	Percentage
1.Early Warning	20%
2.Information Availability	34%
3. Capacity Building	20%
4.Evacuation	40%
5.Search and Rescue	39%
6.Leadership and Coordination	78%
7.Provision of Humanitarian Assistance	79%

8.Initial Damage and Needs Assessment	26%
9.Provision of Early Recovery Assistance	18%
10.Temporary accommodation and repair	20%
11.Rebuilding Houses and Buildings	30%
12.Restoration of Infrastructural Services	8%
13.Re-establishment of Sustainable Livelihoods	29%

Table 11: Maamigili Maldives, Fact Effectiveness

Fact	Percentage
1.Early Warning	80%
2.Information Availability	88%
3. Capacity Building	100%
4.Evacuation	53%
5.Search and Rescue	44%
6.Leadership and Coordination	70%
7.Provision of Humanitarian Assistance	90%
8.Initial Damage and Needs Assessment	60%
9.Provision of Early Recovery Assistance	80%
10.Temporary accommodation and repair	90%
11.Rebuilding Houses and Buildings	80%
12.Restoration of Infrastructural Services	40%
13.Re-establishment of Sustainable Livelihoods	91%

Table 9 indicates the fact percentages calculated from Matara, Sri Lanka data whereas Table 10 indicates the percentages calculated from the Data collected from Pathein District, Myanmar. The Table 11 illustrates data from Maamigili, Maldives.

From the above preliminary data calculations averages were taken for the disaster stages for each country, and compared as illustrated in the Figure 22.
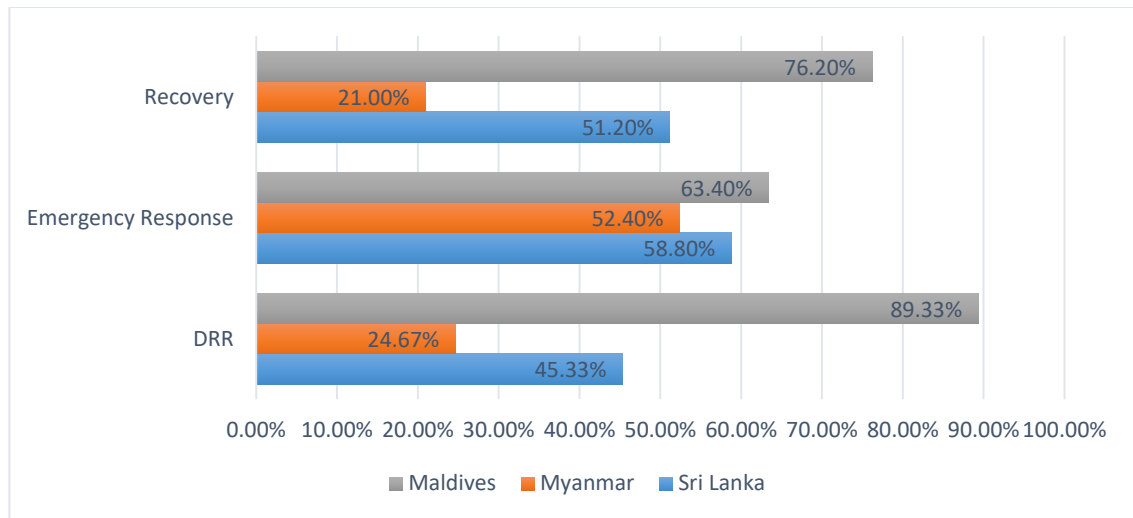
Figure 22: Stage effectiveness of Disaster Management Mechanisms in Sri Lanka, Myanmar and Maldives

5.1.1 Results interpretation

- The effectiveness percentages from Maldives has a significant increment especially in the disaster risk reduction and recovery stages when compared to Sri Lanka and Myanmar. The specific fact of Maamigili is a resettled island is to be taken in to account here. With the resettlement it was efficiently planned to be secured from disasters and also the community was planned on and around the airport in the island. Hence the recovery and risk reduction was in a very much satisfactory level at the island.

- Community ownership in the society made the increment in emergency response stage of Myanmar in disaster management mechanism effectiveness. With that ownership even the community has troubles in evacuation, search and rescue activities which needs support from authorities. If it's coordinated the Myanmar context in the emergency response would be much higher.

- A specific analysis on identifying the fact behind Sri Lanka's higher percentage in emergency response was carried out. There number of elements were excluded from the equation and calculation was conducted. When the external organization factor excluded from the data for Sri Lanka following results were obtained
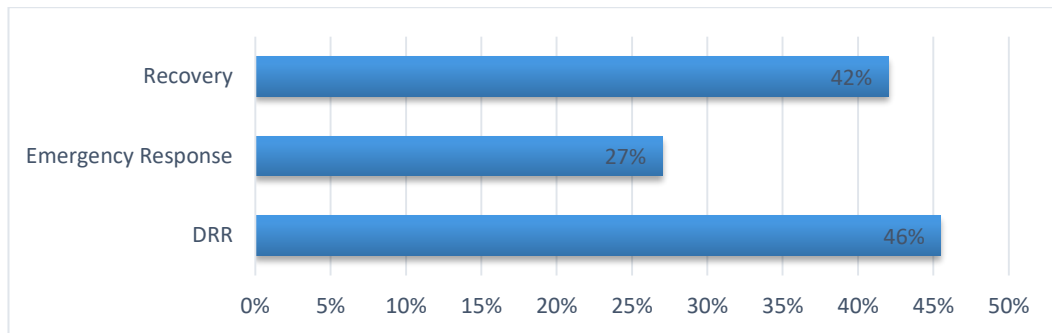
Figure 23: The disaster stage effectiveness of Sri Lanka when the external organizations element excluded from the data

As illustrated from the Figure 23 when the external organization element excluded from the data the effectiveness percentage of emergency response stage drops to 27% from 59%. This result indicate the impact generated by the external organizations in effectively managing the emergency stage of Sri Lankan disaster management mechanism.

5.2   Comparison of Disaster Management (Policies and Institutions)

With the identified disaster management mechanisms from Sri Lanka, Myanmar and Maldives a comparative analysis was conducted as follow, Figure 24.

Property	Sri Lanka	Myanmar	Maldives
Dedicated Policies and laws	✓	✓	✓
Dedicated Ministry	✓	✓	✓
Dedicated Fund	✓	✓	✗
Umberella Mechanism in DM	✓	✗	✓
President to declare state of emergency	✓	✓	✓
Top most body containing the President	✓	✓	✓
Provisions for Externals to participate in DM	✗	✗	✓
Community welfare oriented culture	✓	✗	✓
Dedicated institutions to monitor disaster risk	✓	✓	✓
Availability of Hazard Maps	✓	✗	✓
Use of mobiles and Apps in EW	✗	✗	✓
Use of "Incident Command Systems" for DM	✗	✗	✗
Dedicated institutions to respond to disaster risk	✓	✓	✓
Dedicated mechanism to post evaluate (Report) DM	✗	✗	✓
Direct platforms for experts to provide inputs	✗	✗	✗
Availability of Risk index modelling	✗	✗	✗
Dedicated platforms to research on new trends on DMM	✗	✗	✗

Figure 24: Comparison of Disaster Management Mechanisms of Sri Lanka, Myanmar and Maldives on selected properties

The properties used to compare were selected based on the Sendai framework on Disaster Management. There are number of identified facts as illustrated from the figure 23.

The availability of dedicated policies to govern the disaster risk management, a dedicated ministry (Which reports and empowered bylaw to govern the disaster

management), the process of declaring the state of emergency (headed by the president of the country), the top most body governing the disaster management headed by the president of the country, dedicated institutions to monitor and respond to disaster risks are number of key properties observed to be available in all three countries.

Also the three countries can exchange the knowledge on implementing some of the properties for the disaster management mechanisms. Especially to implement and get the use of dedicated fund for the Maldives, the Maldives National Disaster Management Authority can get the context understandings from both, Sri Lanka and Myanmar. Similarly to make the hazard maps available and to implement the reporting mechanisms countries can exchange the knowledge.

There are parameters such as using the incident command system, which is a mechanism the governing authorities have tried to implement number of times in the history, is an area all the three countries can work on. Countries can use the support of experts in the area and share knowledge with specially countries like United States of America to check the feasibility in implementing such mechanisms.

Taking the expert opinions and creating platforms for researchers and relevant institutions such as higher education institutions to research on and around the risk management methods specially on the area of natural hazards is a key factor three countries can work on to maximize the effectiveness of the disaster management mechanisms.

Generating a risk index is another grey area the three countries needs to work on. The Indonesian model on risk index is a key regional example available to implement and work on. The use of risk index enhances the knowledge capacity on disaster identification and also the vulnerability sector addressing.

5.3 Institutional Comparison

The framework on institutional ranking was used here. The data obtained from the institutional survey were included to the defined criteria mechanism.
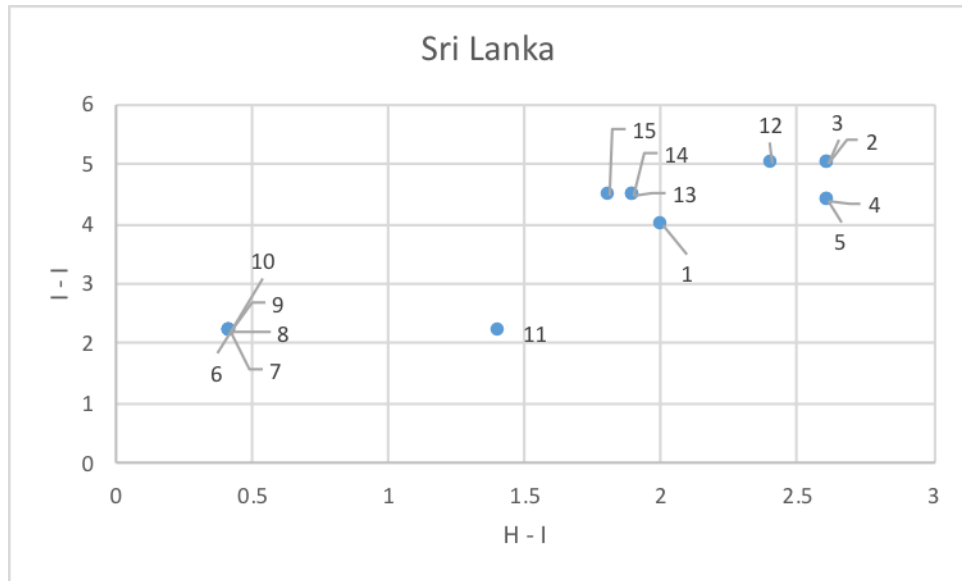
Figure 25: Institutional Map of Sri Lanka
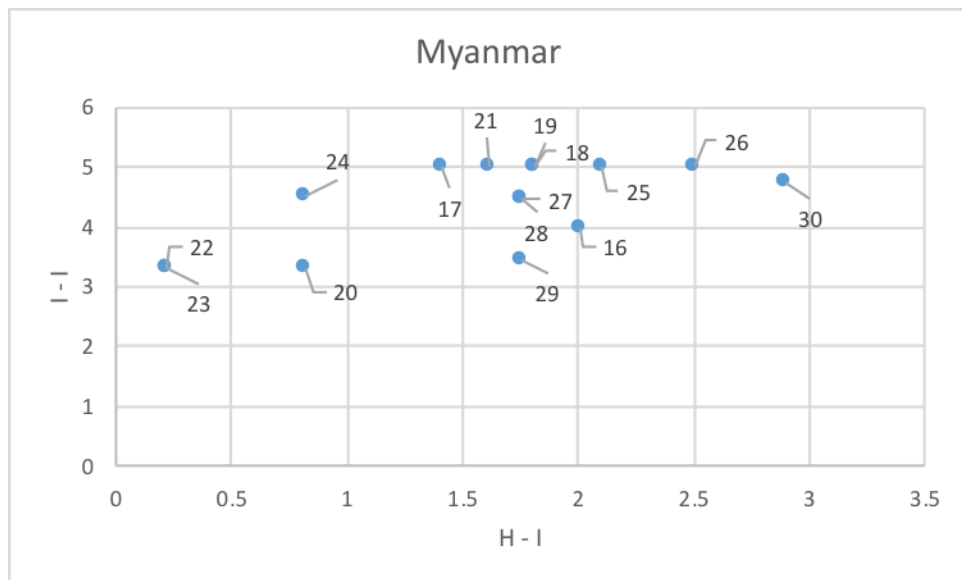
Figure 26: Institutional Map of Myanmar
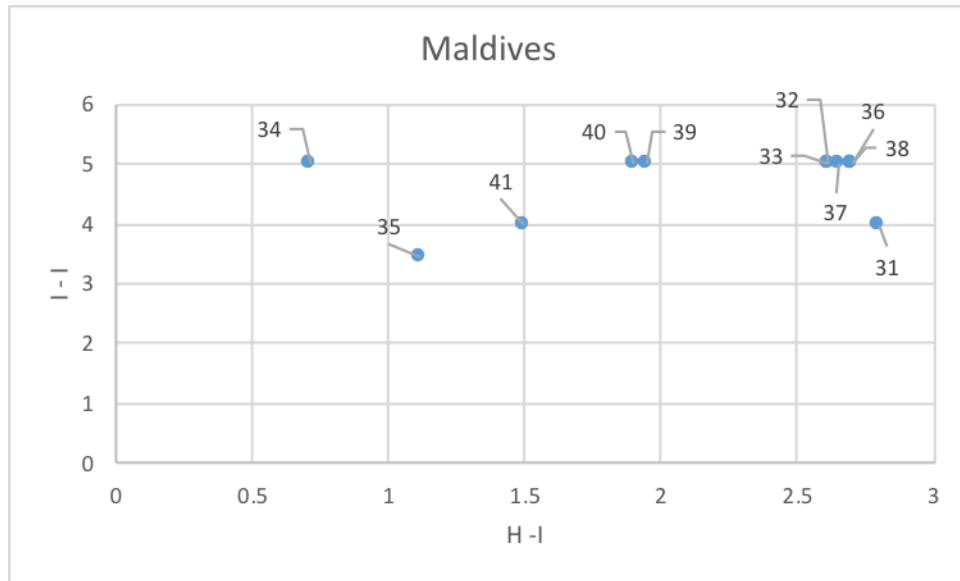
Figure 27: Institutional Map of Maldives

No	Institution	No	Institution	No	Institution
1	National Council for Disaster Management	16	National natural Disaster Management Central Committee	31	National Steering Committee
2	Ministry of Disaster Management	17	State Working Committees	32	National Disaster Management Authority
3	Disaster Management Center	18	Ministry of Home Affairs	33	DRR Unit
4	Ministry of Defence	19	Ministry of Social Welfare, Relief and Resettlement Department	34	Corporate affairs unit
5	Ministry of Health	20	Ministry of Health	35	Meteorology Department
6	Department of Meteorology	21	Department of Disaster Management	36	National Emergency Operations Center
7	Department of Irrigation	22	Asian Disaster Reduction Center	37	National Emergency Response forces
8	National Building Research Organization	23	ASEAN Committee on Disaster Management	38	Maldives National Defence Forces
9	National Aquatic Resources Research and Development Agency	24	Department of Meteorology and Hydrology	39	Atoll DM units
10	Marine Environment Protection Authority	25	Relief and Resettlement Department	40	City DM units
11	Geological Survey and Mines Bureau	26	Emergency Operation Centre	41	Island DM units
12	National Disaster Relief Services Center	27	District Working Committees		
13	Provincial Councils	28	Township Working Committees		
14	District Secretariat Offices	29	Village Working Committees		
15	Divisional Secretariat Offices	30	Armed forces of Myanmar		

Figure 28: Legend for the Institutional Maps of Sri Lanka, Myanmar and Maldives

Figure 25, Figure 26, Figure 27 and Figure 28 illustrates the institutional maps of Sri Lanka, Myanmar and Maldives respectively. There are four visibly identified clusters from the Sri Lankan map.

- Ministry of Disaster Management, Disaster Management Center, Ministry of Defense, Ministry of Health, National Disaster Relief Services Center has obtained high H-I and I-I values

- National Council for Disaster Management, Provincial Councils, District and Divisional Secretariat Offices had fallen in to a moderate category.

70

- Geological Survey and Mines Bureau stands in an unaccompanied manner.

- All the other organizations stands in a separate cluster. These institutions are mainly responsible in risk monitoring and early warning.

Similarly there are clusters definable from Myanmar and Maldives maps as well.

5.4 Risk Diagram

The Risk Diagram is prepared with the use of Rafetry Equation and also by developing the process action groups as mentioned below. There were 5 steps involved in developing the Risk Diagram which is illustrated as a recommended disaster management mechanism.

1. Identifying the elements for each parameter in Rafetry equation.

2. Comparing the identified elements with the frameworks from three country case studies (Sri Lanka, Myanmar and Maldives) as well as with the inasrisk model from Indonesia.

3. Inclusion of the identified action process groups from the correlation analysis.

4. Mapping the identified institutions according to the Rafetry equation and the action process group framework.

5. Concluding and developing remarks with the expert survey to utilize the developed disaster risk management mechanism

5.4.1 Use of the Risk Equation (Rafetry Equation)

The practical application of the risk management in the scenario of natural hazards is directly compared and reviewed using the Equation 3 as a foundation.

$$Risk = \frac{Hazrd \times Vulnerability}{Capacity}$$

Equation 3: Risk Equation by Rafetry

As mentioned in the literature above formulation and the relationship (relationship of Risks and hazard, vulnerability, capacity components) is referred in developing the Risk Diagram. The components in the equation are used to identify the overall elements of the disaster management mechanism.

A specific review on one of the existing Risk Diagram generation mechanism was studied as the next step here to understand the context.

5.4.2 InaRISK Model

InaRISK is a risk model used by the National Disaster Management Agency (BNPB) of Indonesia. InaRISK model consists of 6 outputs mainly, which are produced from

the data collected and stored from organizations locally, regionally and internationally. The outputs are consists with;

- Potential hazards
- Potential population affected
- Potential physical losses
- Potential economic losses
- Potential environmental damage
- Monitoring tool for disaster risk reduction index

The InaRISK tool disseminate disaster risk assessments to the government and to the public. By that the tool support the relevant authorities and institutions to strategize the implementation of programs, policies and activities to mitigate the disaster risk.

The methodology used in the InaRISK model is closely studied for the research work, whereas the model methodology is also based on the Rafetry equation on risk.

Figure 29: InaRISK Methodology

As illustrated in the Figure 29, the Risk Diagram is prepared from the parameters from hazard, vulnerability and capacity. The Risk Diagram is used as the baseline in preparing the disaster management plan for Indonesia.

There are number of relevant parameters defined for each element in the equation.

The hazard map compromised with probability and impact parameters. The data form those two parameters defines the hazard map. Levels of threats defined here using the probability of occurrence and impacts.

Vulnerable map consist of four parameters. Scio-cultural, economy, physical and environment. For each of the parameter a definite tangible facts were defined as mentioned in the Table 12.

Table 12: InaRISK Vulnerable Map

Parameter	Fact
Socio-Cultural	Population Density, %Vulnerable groups
Economy	Area of productive land, GDP of each sector
Physical	House, Public facility, Critical facilities
Environment	Protected Forest, Natural Forest, Mangrove, Swamp, Scrub

The sensitivity of the population is measured on gender base, disable people percentage, age groups, poverty percentage as well on the gender of the head of the family. The productive land area was measured in the means of rice fields, plantation, and agriculture land and fish ponds mainly.

Capacity map is generated with five parameters, namely; Institutional/policy, early warning, capacity strengthening, mitigation, and preparedness. Similar to the vulnerable map there are definite facts defined for each parameter as mentioned in the table 13.

Table 13: InaRISK Capacity Map

Parameter	Fact
Institutional / Policy	Regulation related DM, Institutional related DM, DM in regional development, Disaster Management plan, DM Budgeting
Early Warning	Disaster prone map, Early warning system
Capacity Strengthening	DMP socialization, Curriculum/local content, disaster education, resilient village
Mitigation	Regional planning based on mitigation, structural disaster mitigation
Preparedness	Contingency plan, EOC, Logistic warehouse, Volunteer

Keeping Rafetry equation and InaRISK methodology as two base lines the research work then followed on with the findings obtained from case studies and literature to generate the Risk Diagram for Sri Lankan context.

5.4.3   Primary Model Framework

From overall literature and the surveys on understanding the disaster management mechanisms, there are two major components identified which forms a disaster

management mechanism. Namely Policies and Institutions as illustrated in the Figure 30.
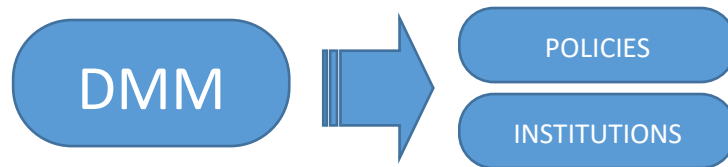
Figure 30: DMM as Policies and Institutions

Policies of the three case studies were identified and presented in the literature chapter. It was concluded that the policies are in place and empower the institutions to perform activities related to disaster risk management. Yet there were problems identified such as repetition of work, disorganized communication channels between institutions, and coordination issues. Hence the question arise whether the institutions are organized systematically to address disaster risk management. With that scenario, to achieve the third objective of the research work the institutional alignment with respect to the risk management, map model was developed.

There were two basic parts identified as the risk equation and the institutional formwork in the Risk Diagram model as discussed above.

The main involvement as well the method of empowerment grated from policies towards institutions are the actions/activities. In the disaster risk management mechanism there are 4 activity process groups identified. Namely; Planning, Identification, Monitoring & Controlling, and Executing.

Planning action process group includes the policy formation, proactive measures, initiation of the work. The identification action process group includes all the research and data collection activities in the disaster risk management process.

Monitoring & Controlling includes the identified sectors close monitoring and plans execution monitoring & controlling. The executing process group includes the plans implementation from top to bottom.

The entire risk diagram outline model basics and the relations illustrated in the Figure 31.
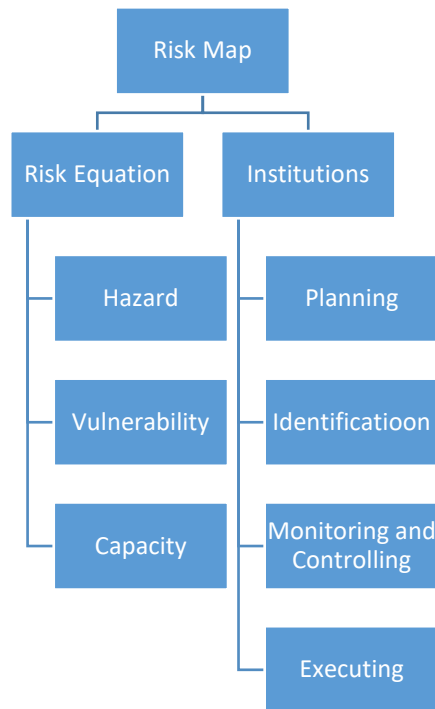
Figure 31: Risk Diagram Primary Framework

5.4.4 Hazard Parameter

Sri Lankan case study on 2004 Indian Ocean Tsunami was specifically referred on defining the hazard parameter and facts. Before 2004 Tsunami Sri Lanka had no mechanisms in place with respect to Tsunamis.

There were no early warning systems in the country by that time. Even it was later found out that the regional and international warning systems were also not connected to the Sri Lankan agencies. It was concluded that if those warnings were well received and acted upon, the damage would have being much less. Hence identifying and having mechanisms, at least processes identification and making the knowledge available is very important for any natural hazard type.

Hence under the hazard parameter, type parameter is added to the Risk Diagram model. Other than to the type parameter, as in InaRISK model, probability and severity (Impact) parameters were defined as illustrated in the Figure 32.
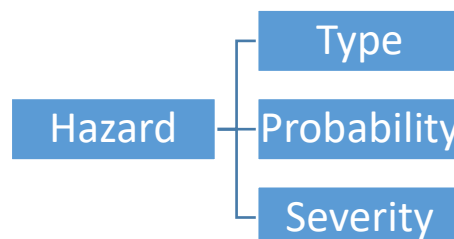
Figure 32: Hazard Parameter and sub parameters

Probability parameter is the return period of natural phenomenon, which in turn counted as the return period for the current year. Severity is to be counted based upon the historical data. Economic and physical losses are compared in this parameter for the given natural hazards.

5.4.5 Vulnerability Parameter

Findings from the three case studies, literature and expert opinions were used in defining the sub parameters and facts of vulnerability parameter.

In the InaRISK model there are four sub parameters, namely; Socio Cultural, Economy, Physical and Environment. For each of the sub parameter there were facts defined to capture the context in its best form. If the facts were reviewed together it's observed that the facts can be reorganized in to three categories mainly. Community related facts such as population density, vulnerable groups, houses, and critical facilities (infrastructure) are one category observed.

Another category observed is the production and industry related facts such as area of productive lands, and GDP. The third and final category observed is the environment and natural facts such as forests, swamp, and scrub.

From this categorization and using the expert opinion and literature the vulnerability parameter is defined with three sub parameters (People, Industry and Nature) and relative facts. The facts relevance to the risk and disaster management is mentioned in the Table 14: Fact relevance for the Vulnerability ParameterTable 14.

Table 14: Fact relevance for the Vulnerability Parameter

Sub Parameter	Fact	Relevance
People	People density	Includes the overall population density of a given area for the risk management. Casualty percentage of a disaster directly proportionate to the population density of area.
People	Vulnerable group %	Increase in the child, pregnant density, disable population increases the damage and casualty percentage of the area
People	% houses	Physical damage to community includes the household damages. Increase in housing infrastructure results in increase in physical damage to the community
People	Utility infrastructure	Lags in infrastructure restoration results in cascaded impacts on the disaster recovery
People	Community buildings	Evacuation building and shelters mostly compromised with the community buildings such as religious places. Also damages to the critical community

		places such as schools and hospitals results in longer recovery periods.
Industry	Industry density	The industry areas impacts from natural hazards are different to the community areas. The damage to the soil, water and air form the industrial resources as well as the overall loss to the physical infrastructure are to be measured.
Industry	GDP contribution	Includes the overall economic loss till the complete recovery after a disaster event.
Industry	Employability	During a disaster event evacuation plans, and other related emergency response are to be included with respect to the number of people employed.
Nature	Corps land %	Corps damage due to hazards takes a major recovery time or non-recoverable. Planning and risk management on this regard is required in the risk reduction stage with corps land selection
Nature	Livestock %	The casualties and death counts from all living beings are to be included here. It is identified that post disaster impacts from livestock can cascade in to further hazards and disasters.
Nature	Forest %	The natural environment disturbance are to be measured and kept in track such that the environment disturbed isn't destroyed permanently.
Nature	Wet land %	On certain specific natural hazards such as Tsunamis, flood the wet lands and related natural attributes act as risk mitigation mechanisms.

With these sub parameter and fact identifications the overall vulnerability parameter is illustrated in the Figure 33.
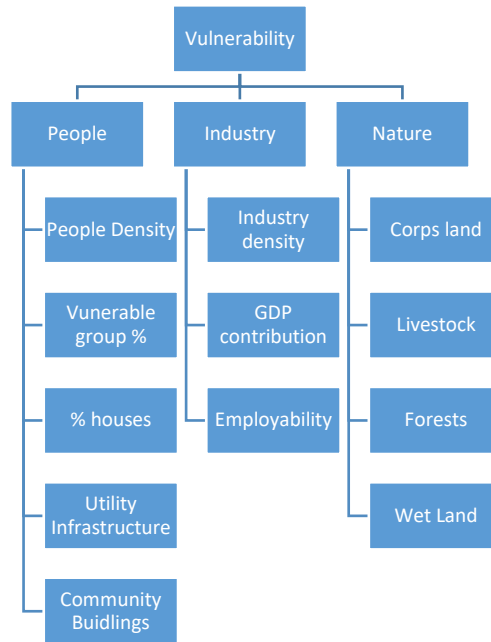
Figure 33: Vulnerability Parameter, sub parameters and facts

Overall there are three sub parameters under vulnerability and twelve facts to illustrate the sub parameters.

5.4.6 Capacity Parameter

Available literature and the expert opinions were used in preparing the capacity parameter. The baseline model, InaRISK, has 5 sub parameters under the capacity. Institutional/policy, early warning, capacity strengthening, mitigation and preparedness namely.

There are number of facts defined in each of the sub parameter as well. Yet again in the context of Sri Lank and also from the case studies there are several other capacity categories identified as governing, technology and knowledge, and preparedness.

There are facts formed under each of the sub parameter. The review of the facts and the relevance of each towards the risk management mechanism in the means of natural hazards are discussed in the Table 15.

Table 15: Fact relevance for capacity parameter

Sub parameter	Fact	Relevance
Govern	Governing Policies	Policy formation and planning is an essential part for the risk management. Here includes the updating and monitoring of the policies as well.
Govern	Financing	Primary facilitation requirement is to provide monetary needs when

		required and having sufficient funds planned ahead.
Technology and Knowledge	Knowledge development	The research facilitation and empowerment to conduct on and around the required risk management and natural hazards are included here.
Technology and Knowledge	Knowledge transfer	The developed knowledge transferring in to the community levels and creating simple mechanisms to flow the knowledge is a requirement in proper risk management.
Technology and Knowledge	Early warning	An essential part in the emergency response stage to effectively mitigate the natural hazards and keeping the technological uplifting is referred here.
Preparedness	Logistics	Capacity on the disaster responding in the means of materialistic requirements, service requirements are included in the fact.
Preparedness	Human resources	Keeping the human resources planning from the top to grass root level in all phases/stages of disasters is mentioned here.

In overall there are three sub parameters defined for the capacity and 7 facts identified. The capacity parameter in relation with the sub levels is illustrated in the Figure 34.
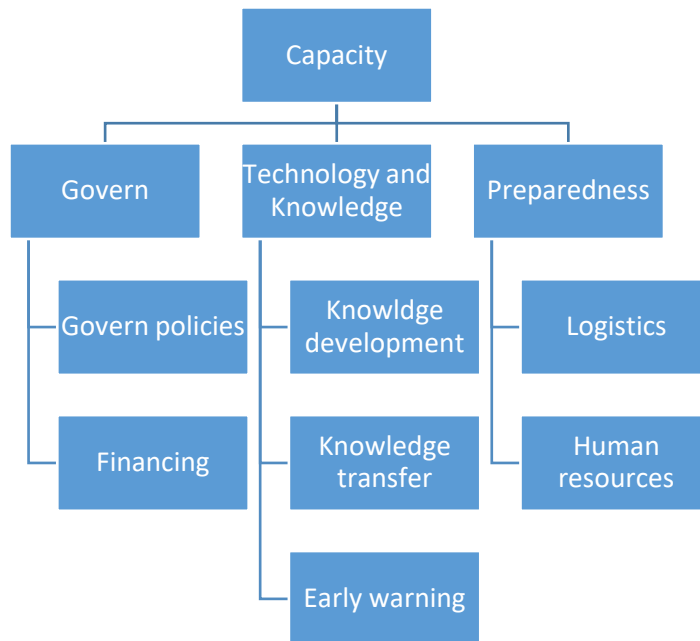
Figure 34: Capacity Parameter, Sub Parameters and Facts

5.4.7 Risk Diagram

With the above identification of primary model framework, Hazard-Vulnerability-Capacity parameters, action process groups and the institutions the final risk diagram model was prepared. A graphical illustration of the model (without institution map) is illustrated in the Figure 35.

The diagram with the institutional arrangement is attached as an annex to the thesis.

In the buildup of the Risk Diagram model after the Rafetry equation, the parameters and facts were defined as per the context of disaster management. Hence the map is to be applicable and to be reviewed one the context of natural hazard induced disaster management. All the institutional arrangement is done according to the Sri Lankan context with the case study inputs. A specific discussion on the diagram is provided with the next chapter on recommendations of the research.
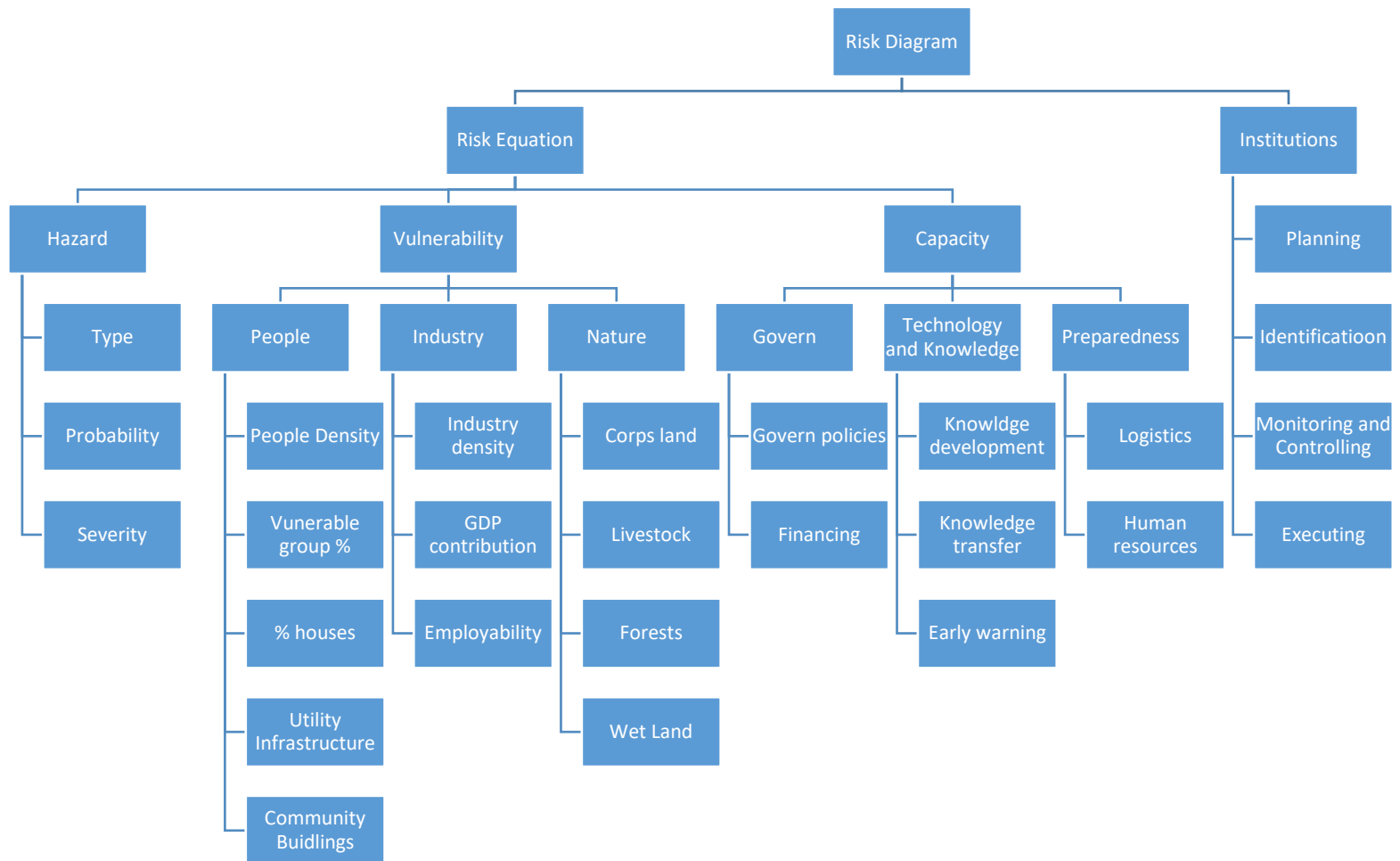
Figure 35: Risk Diagram

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- Engineered solutions are required in the disaster management mechanism development in the context of risk management to effectively address the ever increasing risk of natural hazards.

- Policies related to disaster management in Sri Lanka do have a historical empowerment, whereas Myanmar and Maldives do have policies implemented dedicatedly for disaster management very recently.

- 2004 Indian Ocean tsunami was a breakthrough point in updating and focusing on the disaster management mechanism for all three countries.

- The questionnaire framework captured major parts of the disaster management mechanism and enhanced data to analyze and obtain diverse results. Hence the questionnaire framework is capable enough to capture and evaluate a disaster management mechanism.

- Human – Institutional behavior framework illustrated the behavior pattern of institutions in coordination with other institutions and community. The use of the framework defined way forward for the other frameworks and analysis.

- From the surveys number of gaps and barriers in the disaster management mechanisms were identified. Yet understanding the responsible party/institution in addressing the barrier and making solutions was delayed or non-existed at all in most cases.

- In all three countries the identified gaps were found to be a repetition of another in a different context. Hence it was identified that the case reporting and documenting a legend of lessons learned from past events on disasters is missing in all countries.

- Institutional ranking system provided results in a diverse manner, with clear clustering of institutions in the mechanisms. Hence the criteria's in the institutional ranking system has enough capacity to capture key aspects of institutions in the disaster management mechanisms.

- Sri Lanka do well in emergency response stage of disaster stages. Whereas it was identified that the external organizations such as volunteers who aren't facilitated in the policies make the largest contribution for that stage.

- The empowerment of external organizations for the disaster risk reduction and disaster recovery stages are not observed in the policies of Sri Lanka.

- Disaster risk reduction and disaster recovery stages are having lower effectiveness values when in comparison. The discontinued nature of the

disaster management upstream organizations and the community level results in such. Even though there are plans exist in disaster management the implementation of such absence due to the dis-connectivity nature.

- Community empowerment results in greater effectiveness value in emergency response at Myanmar.

- Plan for disaster risk activities is majorly what DMC and NDMC are empowered in to act upon in Sri Lankan context. There are number of frameworks developed by them with the coordination of the higher education institutions and relevant other authorities. With the context that natural hazards are a frequent unpredictable events, continuous improvement requirement of risk planning is highly questionable in Sri Lankan context.

- National level risk identification with a risk register was not observed in any country. The importance of risk register came in to the clear illustration with the 2004 Indian Ocean Tsunami, with the unavailability of identification of Tsunamis; early warning mechanisms, disaster mitigation plans were missing in regard to Tsunamis in all three countries by the time of 2004.

- In current disaster management mechanisms of Sri Lanka, Myanmar and Maldives, the institutions directly responsible for performing risk qualitative and quantitative analysis is not clear and the policies haven't empowered or facilitated an institution directly.

- NCDM and DMC are well empowered from the governing policies to carry out disaster risk response planning and implementing. This is a prime requirement in accordance with the risk management frameworks.

- Strategy alignment for risk response is happening situationally in Sri Lanka as well as in Myanmar and Maldives. A processed national level directive in strategy selection is missing in all the mechanisms.

- In the means of disaster response plans implementing the policies are directive and empowered the institutions (NCDM and DMC) to carry out the activities in Sri Lanka.

- In Myanmar and in Maldives also the institutions are empowered in that similar way as in Sri Lanka. Yet the implementation mechanisms are much different. Whereas a more community centered mechanism in risk response implementation is available in Myanmar.

- Monitoring of risks aspect is found to be availably empowered in the aspect of monitoring the already identified natural hazards, is observed in all the three countries.

- The risk response plan implementation controlling and research work on all the hazards is minimum or not exists in the current disaster management mechanisms from Sri Lanka, Myanmar and Maldives.

- The current disaster management mechanisms do have attributes from risk management plans in most parts. Yet there were misalignments and non-existence attributes are visible as mentioned in the above conclusions.

- It is not practical to expect a perfect disaster management mechanism in accordance with the risk management framework. A hybrid study and review to include risk management aspects can enhance the effectiveness of disaster management mechanisms.

- The loop holes in disaster management mechanisms and coordination mechanisms can be solved and make the disaster management mechanism in order, if the risk management frameworks are efficiently and practically incorporated in to the existing disaster management mechanisms.

- There are very unique actions and processes in the disaster management mechanisms which are observed in a limited manner in the theoretical risk management frameworks such as;

  - Regional and international knowledge sharing mechanisms in the disaster management

  - Principled driven disaster management from global and national level

  - Risk index frameworks (not available in case studies, but Indonesian model is referred here) at efficient method other than to the qualitative and quantitative risk analysis methods.

- Objective one of the research work, the identification of the disaster management mechanism was concluded with comprehensive understanding of the policies, institutions in place in three countries and with an overall analysis of them

- Second objective of the research work was achieved from the 4 evaluation frameworks developed. Where they successfully captured the unique attributes, gaps, barriers and contexts of disaster management mechanisms.

- Third objective was successfully achieved from the risk diagram. It's the final output of the research work and it is being reviewed under an expert survey to utilize.

- The frameworks were developed by keeping 2004 Tsunami as the base. Can validate the research work for other disasters as well which is a limitation as well as a future direction for the research work.

6.2   Recommendations

There are number of major recommendations developed on and around the recommended Disaster Risk Management Framework as illustrated in the Risk Diagram section.

- The expert panel

One of the major suggestion from the expert survey is to implement an expert panel in the field of disaster management. The expert panel has to be undertaken following actions in disaster management mechanism.

a) Planning for the disaster risk governing policy updates. With the coordination from Disaster Management Center, the expert panel can provide suggestions and work on the planning process activity of governing policy.

b) Identification of the policies required updating. The experts can act as a research panel to investigate on the policy mechanisms and report on the changes, updates and edits required in the policies governing disaster management to the ministry of disaster management directly.

c) National Disaster Management Council and the Disaster Management Center can act as the facilitators for the expert panel by tracking and monitoring the progress of reporting.

d) In the process activity group of executing for governing policy, the expert panel can provide suggestions for a smooth implementation of the policies.

e) In the area of knowledge development for the disaster management activities the expert panel should act as the focal point. The panel to be included in the planning activity process group as consultants. For these actions not only the experts in disaster management but also the experts in education sector to be incorporated in to the panel to enhance the inputs in developing and planning knowledge transferring mechanisms.

f) With the coordination from disaster management center, the expert panel can identify the knowledge areas to be transferred, improved and developed and as well as develop methods to transfer the knowledge.

g) Also in the areas of monitoring and controlling the knowledge development and transfer phases are to be directly monitored and implemented under the supervision of the expert panel.

h) The expert panel to be continuously evaluate the knowledge in disaster management and address by reporting to the relevant authorities to take actions.

i) The overall work of the expert panel is to be facilitated by the relevant ministry of disaster management in monetary and in logistical means and frequently

discuss with the panel for the betterment of disaster management mechanism to govern risks.

The recommendation of the expert panel input was well discussed and reviewed by an expert survey conducted during the research work which enhances the importance and need of having mechanisms to incorporate the academic and expert inputs in the disaster risk management mechanisms.

- Research and continuous improvement facilitation. The governing institutions can implement process to support directly the research work on natural hazards and risk management incorporations to enhance the knowledge and awareness.

- Development of a risk index mechanism is an urgent action, all three countries should initiate.

- National level risk register has to be implemented and updated. Even though there weren't historical data on a certain natural hazard, being proactive and having practical identification mechanisms is must for the risk management approach in disaster management.

- Disaster Management Center with the coordination from HEIs can work on the risk register. Recent trends on all the related natural hazards has to be taken in to the consideration, such as geological hazards and epidemic outbreaks.

- A national level directive on disaster response strategy selection is required to be made and implemented. There are number of organizations who have responsibilities, authority, and field of interest which creates actions in this regard of risk response. For an example, selecting a strategy for the landslide prone area, best strategy can be avoiding. For the lands ministry, NBRO do have to generate actions together. If they act alone the results can be directing to two different response strategies. Hence a national level risk response strategy selection directive is required to effectively manage disaster response.

- Implementation of policies to empower and facilitate external organizations to actively participate in the disaster risk reduction and disaster recovery stages would make the effectiveness of those two stages much higher.

- Implementation of incident command system can enhance the emergency response stage as well as the preparedness elements of a disaster management system.

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Annexes

Annex 1: PMBOK guide review

Project

6.2.1 Project, Program and Portfolio

A project can be managed in a three different ways. As a standalone project, as a project within a program or as a project within a portfolio. Project can be grouped together into a program when the set of objectives and goals are inline. Programs are defined as a group of related projects, subsidiary programs, and program activities managed in a coordinated manner to obtain benefits not available when managed them individually.

Sometimes the use of portfolios in place to effectively manage multiple programs and projects that are underway at a given time. Figure illustrates a sample portfolio structure indicating the relationships with programs and projects.
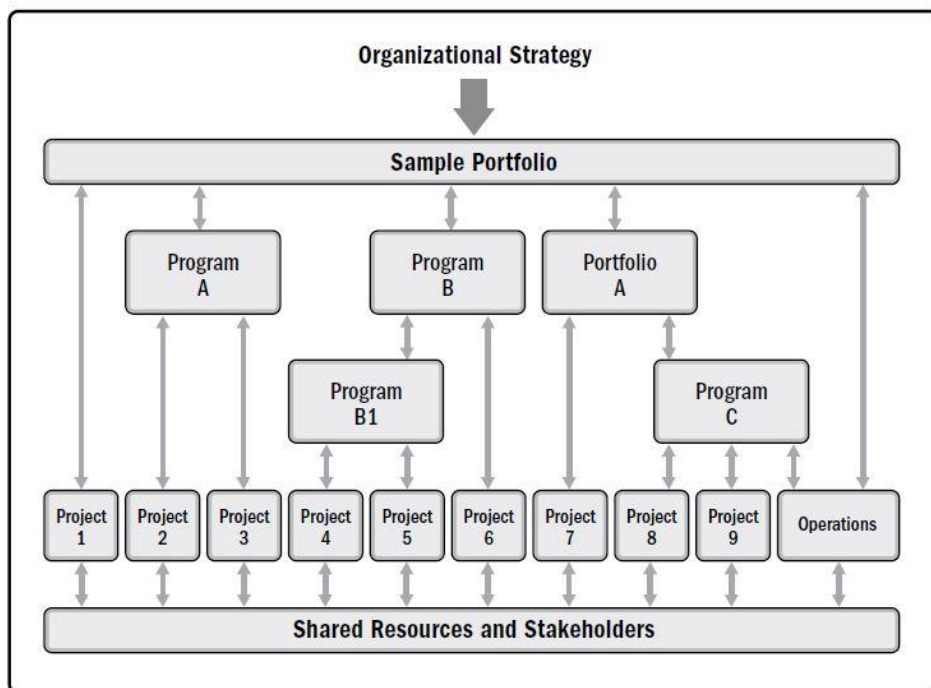
Figure: Projects, Programs, Portfolios and Operations [17]

6.2.2 Project life cycle

The next aspect reviewed on project management is the project life cycle. PMBOK guide defines project life cycle as the series of phases that a project passes from its start to end. The phases are sequential, iterative or overlapping. These logically related

project activities that culminated in the completion of project deliverable forms project phases. Any project can be mapped in to a general life cycle as shown in the *Figure*.
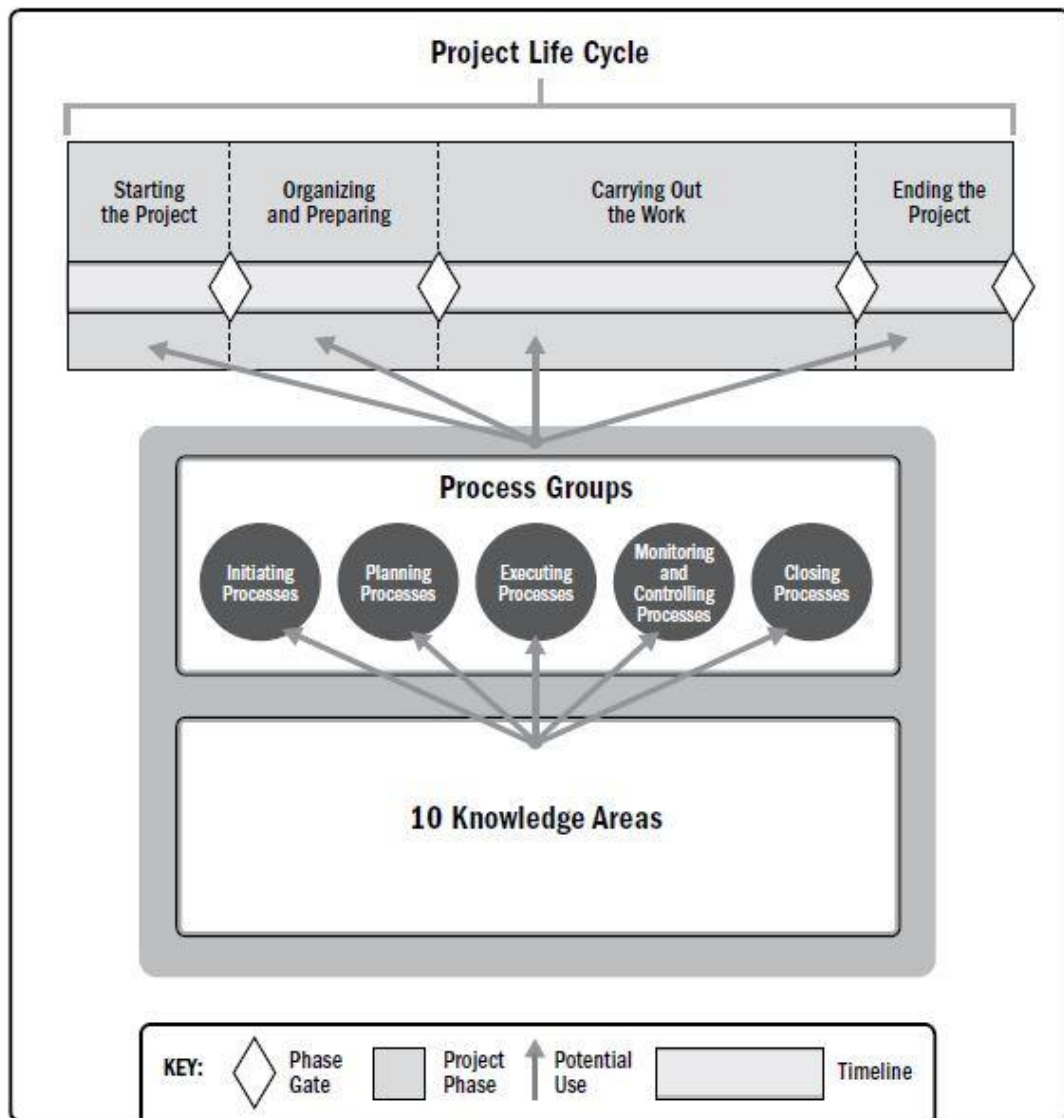
Figure: Project life cycle and interrelationships with key components in Project Management

There are five project process and 13 project management knowledge areas defined in the PMBOK Guide and a comprehensive review of such is provided in the annex on PMBOK Guide review.

The PMBOK Guide defines a project as a temporary endeavor undertaken to create a unique product, service or result.

- Unique result, service or product

Projects are initiated to achieve an objective by producing a desired output. The output can be a unique product that can be an enhancement or correction to an existing item or a new item in itself. Or the output can be a unique service or a capacity development to perform a desired service. Or the output can be a predefined unique result such as a report. Or the output can be a combination of the above. Initiation of incident command system for the disaster management mechanism, or policy reform in the disaster governance are some of the examples in projects in the area of disaster management. Yet the entire disaster management mechanism stand as a project service in which address an objective of managing and providing service to unique incidents in the form of natural hazards.

- Temporary endeavor

Projects do contain a definite beginning and an end. Even though projects are temporary the outputs and deliverables form a project exists even after the end of a project. For an example a policy reform in the disaster management starts with the ideology of respective institutions identifying the need to reform and the project ends when the policy reform is completed. The reformed policies then on stand and empowers the process and mechanism of disaster management.

- Projects drive change

In a mechanism, in a process or in an organization, a project directs to move the system from current state to a different state. Current state to the future state transition is an output from a project to achieve its desired objectives. For an example from the current state of mechanism, with the objective of further improving the effectiveness of the disaster management, the project of reforming policies drives the entire mechanism to a different state (future state).

- Projects enable business value creation

The benefit created for the stakeholders as a result of a project is referred as the business value in PMBOK Guide. The benefit can be monetary tangible output or an intangible output such as the public benefit. A project to enhance the effectiveness of a disaster management mechanism utilize the sources available in an economic, social and environmental manner. Which in result is the benefit for the community, government and for the nature as well.

- Projects initiate context

Meeting regulatory needs, stratifying stakeholder needs, enhancing the business strategies, or to enhance process and services are four fundamental categories in which the organizations seek to initiate projects. These are the factors in which projects response which illustrate the context of a project. Disaster management mechanism enhancing projects do keep the institutions related viable and tries to deal with the above facts by proving means for organizations to successfully implement changes.

Project Management Definition

Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. [17] The failure to apply project management methods in to a project will result in cost overruns, quality degradation, unsatisfied stakeholders and specially failure in achieving the desired objectives of the project.

There are number of projects in example which are delayed due to the under average implementation of project management techniques. Even in the disaster management field the under satisfied community and lower effectiveness is due to the failure in implementing project management processes in to the mechanism. A reputation loss of the mechanism, including the degradation of the trust of the community are cascading results of such.

The interaction of project management processes in to the disaster management is required to be updated and to continuously improve the mechanisms. It enhance the satisfaction levels of stakeholders and community. And more importantly the solution generation mechanism would be much efficient and solves the issues around. Project management techniques enhance the capacity of managing constraints, while responding in a timely manner. Especially in the disaster management field there are number of stakeholder to be managed and the entire process has constraints and influences from different parties. The use of project management techniques can balance the influence of constraints on the projects on disaster management.

Also the resources allocated for disaster management is very limited. Yet the impact from natural hazards on resources (economic, natural, social, and industrial) are unpredictable. Given that scenario to effective utilization of the resources available for the benefit of everyone the use of project management is a must.

Project Management Process Groups

The logical grouping of the project management processes to achieve the final project objectives is defined as the project management process groups. There are 5 process groups as follows.

- Initiating process group: to define a new project or a phase when a project is initiated are process here

- Planning process group: the refining of project objectives and scope defining to attain the final project objectives are processes here

- Executing process group: processes formed to achieve and complete the work are defined processes here

- Monitoring and controlling process group: reviewing, tracking and regulating the project work to keep and control the achievement of project objectives are processes here

- Closing process group: formal completion of project processes are defined here

Project management knowledge areas

Project processes are also categorized under knowledge areas, where knowledge area is an identified area defined by knowledge requirements.

- Project integration management

- Project scope management

- Project schedule management

- Project cost management

- Project quality management

- Project resource management

- Project communication management

- Project risk management

- Project procurement management

- Project stakeholder management

Above are the ten knowledge management areas. Project risk management concepts and processes are in depth reviewed for the research work.

Annex 2: The Evaluation Framework: Questionnaire

Stage	Fact	Attribute	#	Question
DRR Stage	1.Early Warning	Time	1	How many days ahead were you notified about the flood?
		Mode	2	Were any of the following medias involved? Newspaper/TV/Radio/Social Media
		Reliability	3	Was the news you received credible?
		Accuracy	4	In days, how accurate was the news you received?
	2.Information Availability	Past data	5	By the time of the flood, did you know the level of flood during the 2017 May flood?
		Geological knowledge	6	By the time of the flood, did you know the safe locations?
		Geological knowledge	7	By the time of the flood, did you know the evacuation route from the area?
		Physical structure	8	By the time of the flood, were you aware about the unstable structures in the area?
		Economic knowledge	9	By the time of flood did you had an idea about impact on income method?
		Health knowledge	10	By the time of the flood, did you know about the health related aspects of the flood?
	3. Capacity Building	Activities	11	Were any drills, seminars etc. conducted after the May 2017 flood?
		Physical Development	12	Were any development related activities carried out on drainage/water bodies around?
		Exposure	13	Was there an increment in area/people exposed to the flood?
	4.Evacuation	Necessity	14	Was it required to evacuate from your house during the flood?

Emergency Response Stage		Time	15	If yes, how long did it take to evacuate?
		Assistance	16	Was any assistance or guidance given to you during evacuation?
	5.Search and Rescue	Requirement	17	Were you able to evacuate by yourself?
		Involvement	18	If No, did you receive any outside help?
		Time	19	How long did it take to get help?
	6.Leadership and Coordination	CBOs	20	Did you have a community driven society to help each other during the flood?
		Community leader	21	Have you experienced a situational leader/s emerge during the flood?
		Guidance	22	At any point during the flood, did you receive instructions on what to do next?
	7.Provision of Humanitarian Assistance	Involvement	23	Did any NGO, GO help you get provisions during the flood?
		Effectiveness	24	Provisions you received were, Not enough/ Enough/ Too much
	8.Initial Damage and Needs Assessment	Checking	25	Did GN or a representative gather information from you?
		Effectiveness	26	Was there a follow up on what was acquired?
Recovery Stage	9.Provision of Early Recovery Assistance	Financial	27	After the disaster, did you receive any compensation?
		Knowledge	28	Was any assistance or guidance given to you on how to recover?
	10.Temporary accommodation and repair	Requirement	29	Did you require any temporary accommodation?
		Fulfillment	30	If yes, how long did it take to find one?
	11.Rebuilding Houses and Buildings	Time	31	How long did it take to rebuild any household damages?

		Money	32	Was any monetary/nonmonetary support provided for rebuilding?
	12.Restoration of Infrastructural Services			
		Water	33	How long did it take to access drinking water without provisions?
		Electricity	34	How long did it take to get uninterrupted electricity?
		Accessibility	35	How long did it take to use the roads again?
	13.Re-establishment of Sustainable Livelihoods			
		Economic	36	How long did it take to get back to your work/job after the flood?
		Human	37	Were any lives (Human + Animal) lost due to the flood?
		Physical	38	Were you able to build back on all the physical damages?

Annex 3: Risk Diagram with Institutional Arrangement

Risk Eq			Action process groups			
			Planning	Identification	Monitoring and Controlling	Executing
Hazard		Type	MET	MET	MET, DMC, NDMC	DMC
		Probability	MET	MET	MET, DMC, NDMC	DMC
		Severity	MET	MET	MET, DMC, NDMC	DMC
Vulnerability	People	People Density	-	Census Department	NDMC, DMC, Census Department	DMC
		Vulnerable group %	-	Census Department	NDMC, DMC, Census Department	DMC
		% houses	-	Census Department	NDMC, DMC, Census Department	DMC
		Utility Infrastructure	-	WSDB, CEB, RDA, Local Governmen	NDMC, DMC, Census Department	DMC
		Community Buildings	-	Local Governments	NDMC, DMC, Census Department	DMC
	Industry	Industry density	-	Enterprise Authority	NDMC, DMC, Enterprise Authority	DMC
		GDP Contribution	-	ty, Central Bank, Treasury, Departn	NDMC, DMC, Enterprise Authority	DMC
		Employability	-	Enterprise Authority	NDMC, DMC, Enterprise Authority	DMC
	Nature	Crops land %	-	sus Department, Ministry of Agricul	MC, DMC, Ministry of National Poli	DMC
		Live stock %	-	sus Department, Ministry of Agricul	MC, DMC, Ministry of National Poli	DMC
		Forest %	-	st Department, Ministry of Environr	MC, DMC, Ministry of National Poli	DMC
		Wet land %	-	Environment, Department of Coas	MC, DMC, Ministry of National Poli	DMC
Capacity	Govern	Governing policy	Expert Panel, NDMC	Panel, Ministry of Disaster Manage	NDMC, DMC	Expert Panel,NDMC, DMC
		Financing	Treasury	cal Governments, CB, Department o	NDMC, DMC	Treasury
	Tech and Knowledge	Knowledge development	Expert Panel, DMC	HEIs, DMC	Expert Panel, NDMC, DMC	DMC, HEIs, Local Government
		Transfer	DMC	DMC	Expert Panel, NDMC, DMC	DMC, Local Government
		Early Warning	DMC, MET	MET	NDMC, DMC	DMC,MET, Media
	Preparedness	Logistics	DMC, Local Governments	Local Governments	DMC	Local Government, DMC
		HR	DMC, Local Governments	Local Governments	DMC	Local Government

Annex 4: Journal Publication, International Journal of Disaster Resilience in the Built Environment, January 2020

Barriers and Enablers of Coastal Disaster Resilience – Lessons Learned from Tsunami in Sri Lanka

Abstract:

Purpose - This research exertion evaluates 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 towards 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.

Approach/Methodology – The 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.

Key Words: Disaster Management Framework, Coastal Disaster Resilience, Barriers and Enablers

Paper Type: Case Study

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 [54]. The earthquake which generated the tsunami had a magnitude of M_w 9.3, making it the first "extreme" earthquake since the 1964 earthquake [55], [56]. 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 [57], [58].

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. Since Sri Lanka had not experienced tsunamis in the recent past prior to 2004, the country was woefully unprepared to face such a disaster [59]. This was one of the reasons for the high number of losses, as Sri Lanka did not possess any standard tsunami Early Warning mechanisms at the time [11].

The studies done 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 years to 1000 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 [54]. 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. 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.

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 consisted of 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.

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, in order 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 [65]. Figure 36 illustrates the structure of the NCDM [66].

Sri Lanka has also defined other policies and guidelines for disaster management such as the National Policy on Disaster Management (NPDM), which looks at increasing the country's resilience against disaster risks, the Comprehensive Disaster Management Programme (CDMP), which provides a comprehensive investment plan in order to minimize the impact on the citizens' livelihood and the country's economy in the face of a disaster, the National Disaster Management Plan (NDMP), 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 (NEOP), which provides the Standard Operating Procedures (SOPs) 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) of Sri Lanka works with a number of inline ministries and organizations in activities of DRR and it also coordinates with the NCDM. Figure 37 shows the structure of the various departments under the MDM [67]. With these overall upstream organizational structures, the Disaster Management Centre (DMC) acts as the focal point in coordinating lower-level agencies as illustrated in Figure 38 [68]. 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.
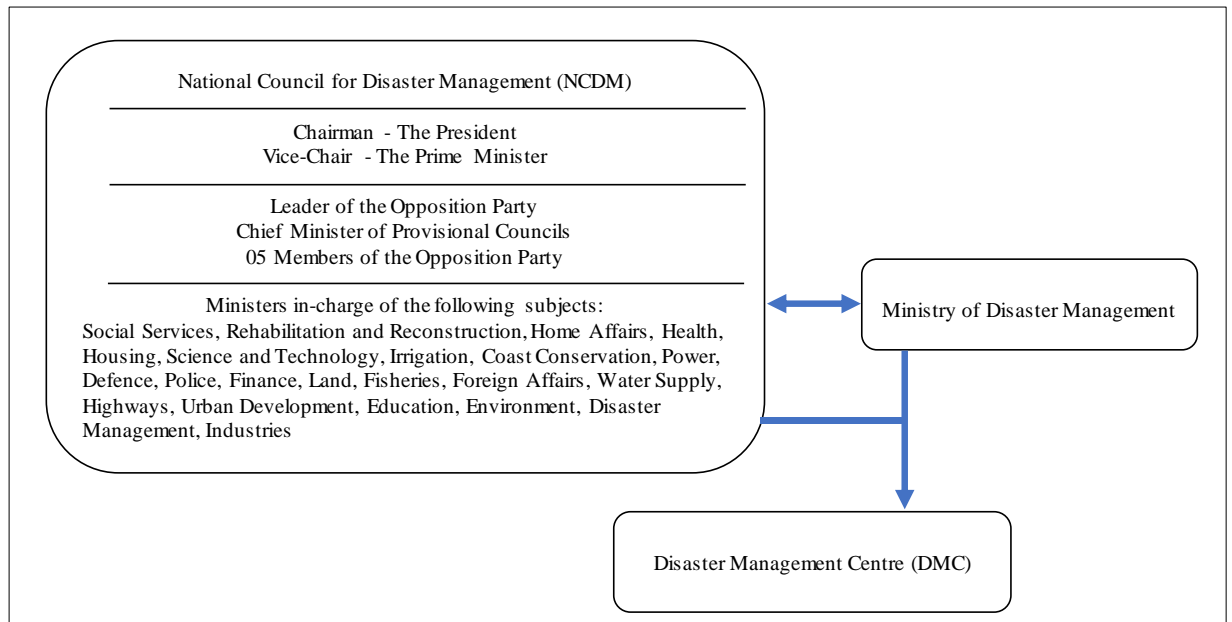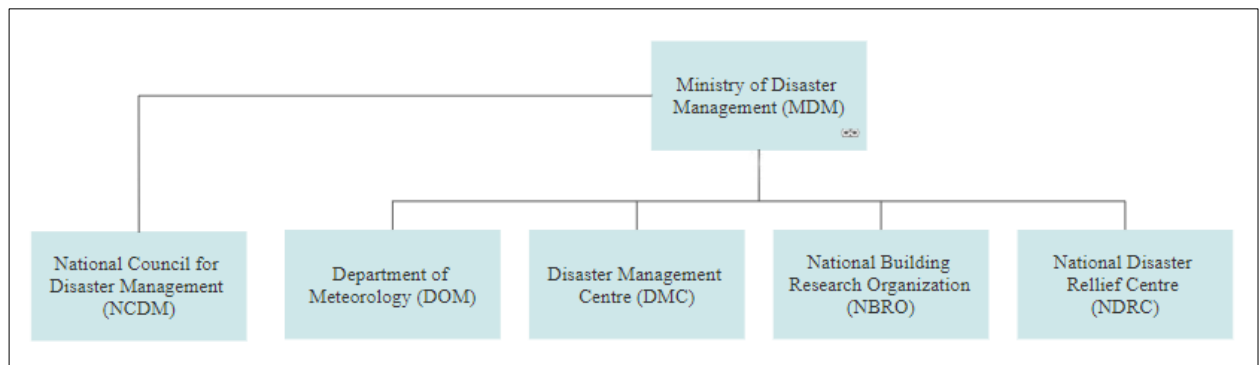

Figure 36: Structure of the NCDM [66]

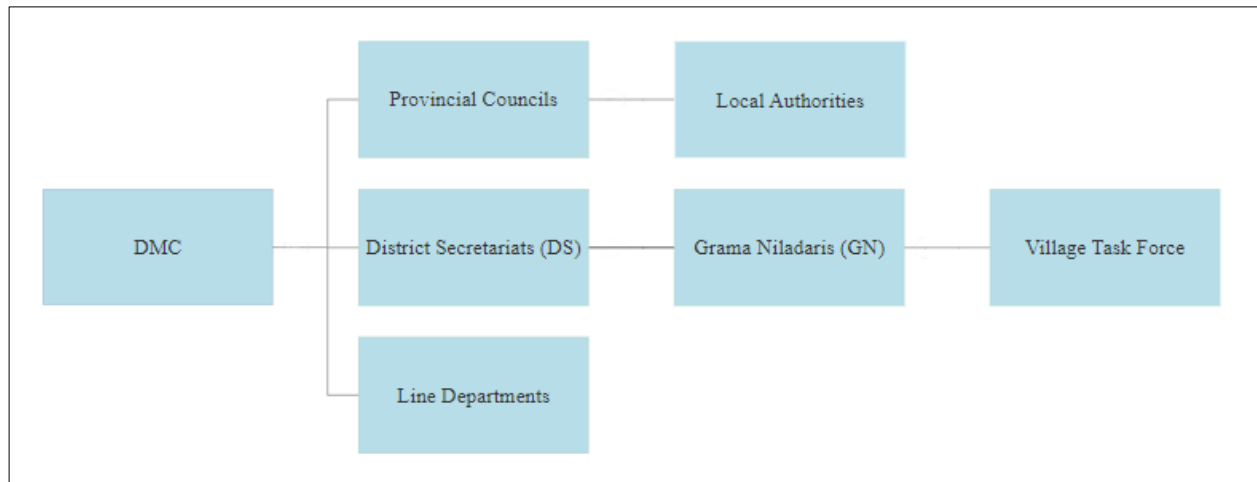Figure 37: Organizational Structure of the MDM [69]

Figure 38: Coordination between DMC and lower-level agencies [68]

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 [70] as was seen during the aftermath of the 2004 IOT, where over 500 international aid organizations were involved in recovery and rehabilitation work [71]. 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 due to the involvement of external bodies such as the armed forces and political influences. This directly showcases the negative impacts due to 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 due to 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 [72]. 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 [73]. 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 four years [74].

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 towards the vulnerable community level. Different web-based and mobile-based applications have evolved in order 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 (GIS) can be used to generate hazard maps and risk maps in order 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 [76]. 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 towards the identification of community exposure towards different modes of receiving Tsunami Early Warnings (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 compared to novel digitally enhanced applications. This can be interpreted more in Figure 4.
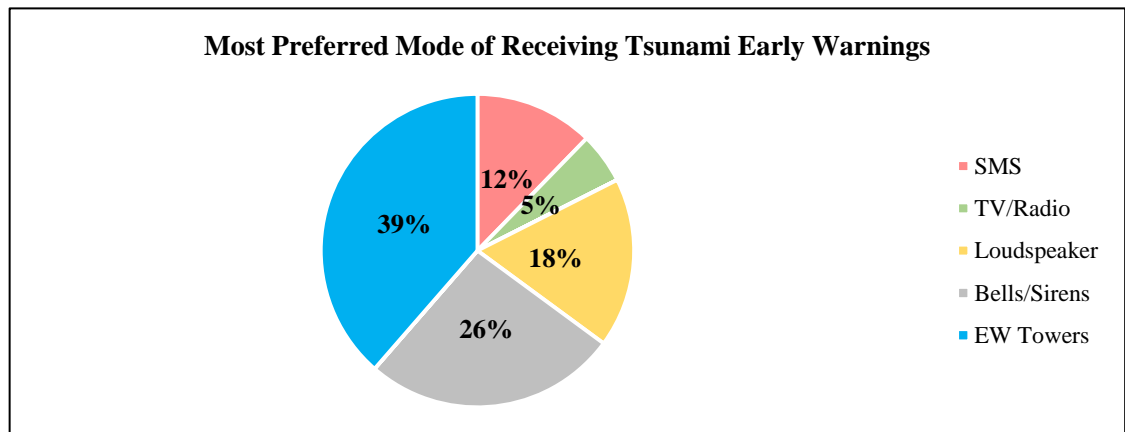
Figure 39: Community response on the most preferred mode of receiving Tsunami Early Warnings

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% 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 40. during the interviews, the administrative officials revealed that the siren had been audible up to a maximum distance of 1000m during the drills that had been conducted. The audible area is marked from the black circle in Figure 40. 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.
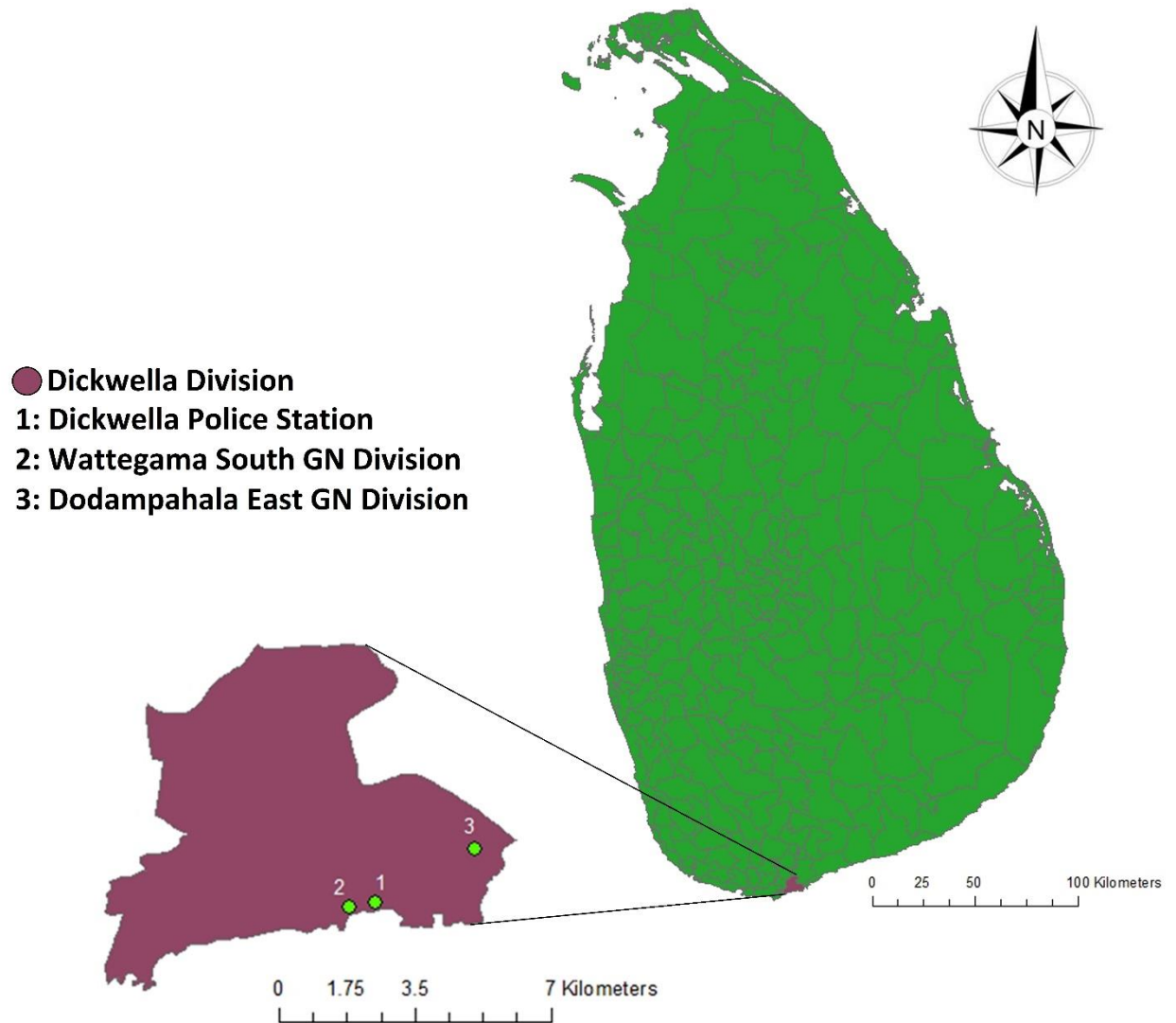
Figure 40: EW tower location and GN Locations in Matara Dickwella

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 like Facebook, Twitter have ranked as the most efficient modes of delivering EWs in other countries over the world [77]. 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 at a lower level. 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 which 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% 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% of the interview respondents were reluctant to respond to EW messages and 75% of them have no faith in the EWs received.

Implementation of Evacuation Plans

Disaster Evacuation

Implementation of evacuation planning is a key segment that is considered under Coastal Disaster Resilience and Management in order 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 [54]. 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 [59]. 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 in order 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% of the interviewees currently follow this practice.

The study in the two GN divisions revealed that 40% of the residents are reluctant to evacuate from their property during a disaster. One reason for this is due to 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.

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. [74].

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 like 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 being in lowland areas, making them unsuitable to be used as evacuation shelters during coastal disasters.

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% had been restored [54]. Out of the interviewees, 32% 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% 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% 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% 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 of 2005, pipeline water provision was restored to all citizens who were served prior to 2004 IOT [78]. 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 USD 2 billion [59]. 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 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% 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% to 8-10% in the following 3 years after the 2004 IOT [79].
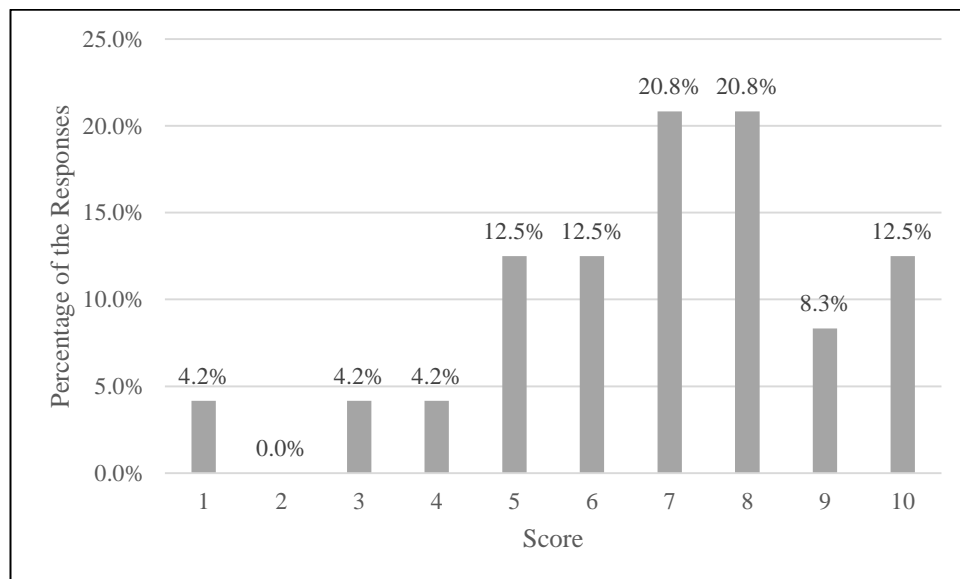

Figure 6: Satisfaction of governmental involvement during the 2004 IOT aftermath

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, 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 towards 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 in order 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 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.

   e.   Not all existing barriers are tangible
   f.   There is a repetition of the same gap in various context
   g.   The main responsible authority or stakeholder of barriers can vary or remains the same
   h.   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 Department of Meteorology (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 in order 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 due to existing political and economic conditions in the area [81]. Therefore, in order 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.

Figure 7: Barrier network

Disclaimer

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.

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_2=&bt_1=&bt_10=&st_10=&ge_9=&le_9=&bt_3=&st_3=&type_19=EXACT&query_1 9=None+Selected&op_17=eq&v_17=&bt_20=&st_20=&bt_13=&st_13=&bt_16=&st_1 6=&bt_6=&st_6=&ge_21=&le_21=&bt_11=&st_11=&ge_22=&le_22=&d=7&t=101650 &s=70 (accessed Aug. 19, 2019).

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Annex 5: Journal Publication, External Interventions for Disaster Risk Reduction, Impacts on Local Communities, January 2020

Lessons Learned from Interventions of External Organizations in Disaster Management: Case Study of Floods in Kalutara, Sri Lanka

ABSTRACT

During 2016, 2017 and 2018 May, Sri Lanka witnessed extreme rains that triggered flooding in many districts. The number of affected people from 2018 floods was around 150,000 which shows a significant decrease compared to the events in 2016 and 2017 where the affected population was 340,000 and 700,000 respectively. A number of external organizations provided their support via funding, relief and rehabilitation mechanisms during these consecutive disasters. A question that need to be answered is does the current Disaster Management Mechanism in Sri Lanka is capable of getting the maximum use of these organizations as well as how well do these external organizations perform in the existing mechanism. The following chapter was generated after a research survey conducted at Kalutara, Sri Lanka an area in the western province of Sri Lanka which frequently gets flooded. Further, the chapter discusses the behaviour of the Sri Lankan community using Hofstede Insights, Humanitarian involvement in Disaster management framework, involvement of external organizations, and then evaluate the effectiveness of the external organization's involved in disaster management stages. An evaluation framework used to access the mechanism is thoroughly discussed. This chapter finds that Sri Lanka does well in the emergency response stage of a disaster and that stand out effectiveness in that stage is due to the involvement of external organizations.

KEY WORDS
Emergency Response, Post Disaster Management, External Organizations, Cultural Dimensions

INTRODUCTION
Sri Lanka, a tropical island situated between latitudes 5°and 10°N, and longitudes 79° and 82°E in the Indian Ocean has weather very sensitive to the changes in the Bay of Bengal. The climate of Sri Lanka is dominated by topographical features as well as the Southwest (May - September) and Northeast (December – February) monsoons. Other than those two monsoons Sri Lanka do experience first inter (March – April) and second inter (October – November) monsoon seasons. The overall wind patterns of the monsoon seasons as well as the changes in the timeframes are possible and depend upon the behavior patterns of the Bay of Bengal. [4]

Most of Sri Lankan natural hazards are caused by hydro-meteorological hazards such as floods, high winds, landslides, etc. of which floods are most predominant. Since 1965, due to the floods, 224,760 houses were damaged. Whereas 128,705 houses damaged due to high winds and, 105,293 houses due to tsunami and 14,761 houses from landslides. Throughout the last four decades, floods have been the main tragedy that affected the most number of families in Sri Lanka. At existing conditions, flood risk reduction is taken into consideration by pertinent authorities taking extenuation actions to save lives and properties [5].

As mentioned, southwest and northeast monsoons account for a major share of annual rainfall [4]. When perceiving the flood pattern of Sri Lanka for the preceding three years, the highlighted factor is the May flood, which starts being a cyclic hazard for the past three years.

IN 2016 total affected people from the May flood were 340,000 whereas in 2017 it was 630,000. When it comes to 2018 during the first week of the flood total impact was 45,680 people [82]. With these facts, the case study selection is further elaborated in the context part of this book chapter.

Next to these disasters, there are number of disasters occurred due to human activities in Sri Lanka. The country report from International SOS in May 2019 describes all sorts of disasters in Sri Lanka. A civil war lasted about thirty years, brought generations' long damage to the country which remains a major disaster of the country. This long community disturbance and social unrest had a major influence in shaping community relationships. Even though that is developed from a human made disaster, at all levels of disasters community thrive for actions when given the opportunity. Hence it is important to understand the status of cultural behaviors of Sri Lanka to further understand the involvement of external organizations, which are based on community interactions. [83]

Sri Lanka has a culture of collectivism, hence, the inter and intra links of individuals, plays a vital role in any community based activity. As mentioned in the background comparatively a low score in masculinity (10 out of 100, figure 1) indicates the feminine characteristics of the society of Sri Lanka. A feminine society has dominant values such as caring for others and quality of life is appreciated in development.[42]. Insights from the research done by Hofstede 2019 on cultural dimensions for Sri Lanka is comprehensively presented in the literature review. A conceptual format designed to illustrate the human and institution interactions is presented in the context part of the book chapter.

The pinnacle of these interactions are visible when the system (community) is in a disturbance, like disaster. Human – Human (H-H) interactions as well as Human – Institution (H-I) interactions generate a significant impact in disaster management process which can be positive or negative depending upon the context it works on. One critical observation which can be made is that during recent floods voluntary groups were formed using H-H interactions whom extend a helping hand to their fellow community. In Sri Lankan context there are two parts to these interactions. Organizations formed within the affected community and organizations formed external to affected community. In this research work the external elements were identified as the institutions, people or organizations which are not part of the system in its undisturbed state and involved in the system when it's disturbed, where the system is the flood affecting community. These external elements can be temporary or long term established institutions from an outside system.

A question need to be answered *"is the system capable of getting the maximum use of these organizations? As well as how well do these external organizations perform in the disaster management process?"* Identification of the institutions and processes in disaster management and gaps which leads to an increment in the total affected people is a timely need for Sri Lanka. In this context number of research activities were carried out in the areas of Social network analysis [43], Evacuation planning [84], Coastal hazard mitigation [84], Community resilience measurement approach [85],   to understand the Sri Lankan disaster management frameworks' application in these disasters, institutional and external stakeholder involvement in the disaster life cycle, evaluating the effectiveness of the process and also to understand the gaps of the process. These research activities are the basis of this book chapter where data were analysed with respect to the external organizational performance in disaster management mechanism. For this book chapter, 2018 Kalutara, Sri Lanka floods was taken as a case study. A comprehensive discussion on the selection of the case study is in the context of the chapter.

BACKGROUND

Five areas were focused on desk studies in the research exertion. A thorough literature review was conducted to summarize and understand the background.

- Social and cultural behavior of Sri Lanka, where the objective was to identify the key facts which influence the community relationships which leads to the formation and operation of external organizations in Sri Lanka. Hofstede insights on cultural dimensions were used to identify and compare the situation of Sri Lanka.
- Humanitarian involvement in disaster management.
- Understanding of Sri Lankan Disaster management framework to identify the policies directed at external organizations
- The practical scenario of the intervention of external organizations in disaster response at management in Sri Lanka.
- The framework used to evaluate the effectiveness of the disaster management system. The development and framework of it and how further enhanced to capture the impact from external organizations.

The context of the above points is comprehensively discussed in the following sections.

1. Hofstede Insights on Cultural Dimensions – Country Comparison

To understand the cultural behaviour of Sri Lanka, Hofstede insights were used. Hofstede
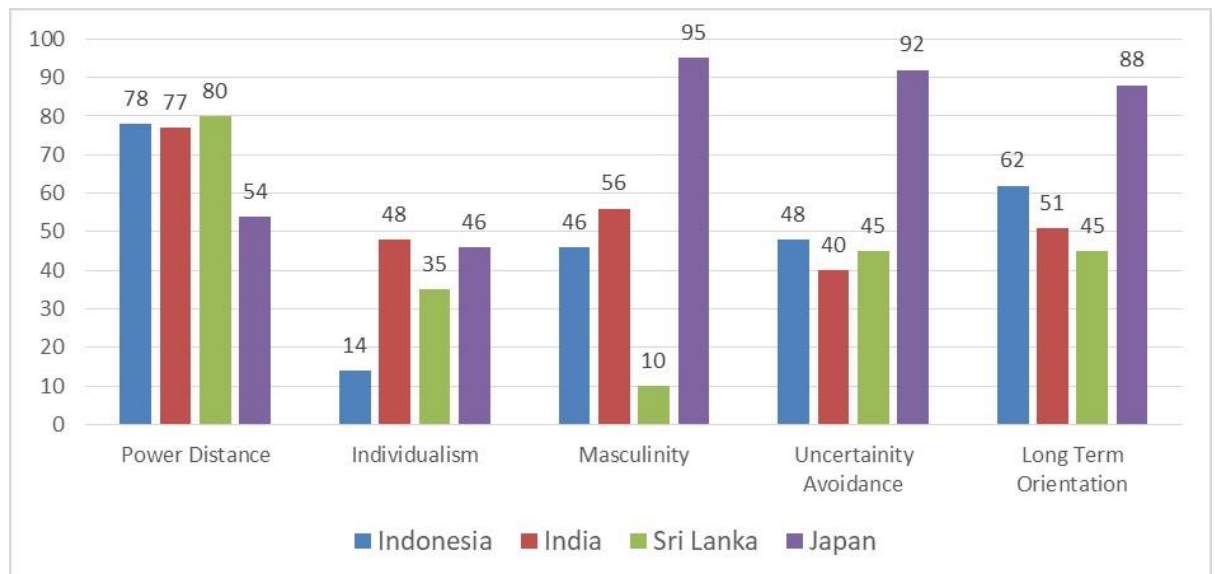
insights compromised six dimensions, Power distance, Individualism, Masculinity, Uncertainty avoidance, Long term orientation, and Indulgence. There is currently no value for Indulgence for Sri Lanka. Hence other five values of Sri Lanka were illustrated and analyse by comparing against three other nations. India, Japan, and Indonesia (Regional countries with frequent hazard profiles).

The following diagram is a comparison of values of Sri Lankan culture in five dimensions when compared to Indonesia, India and Japan. [14], [36]

Figure 1 Hofstede Insights of Sri Lanka when compared to Australia, India and United States - Source: [14], [36]

As per figure 1 Sri Lanka has a higher power distance (80) which indicates a structured hierarchical society which has distinct social norms for each social strata. Hence, usually the power is centralized and it is expected to be direct the lower levels on how and what to do in all aspects. During the case studies it is observed how the communities perceived the managing recovery phase of the disasters (floods) as a responsibility of the government, where they expect the government to provide assistance to build back and recover in the long term.

Collectivist social behaviour of the community is indicated by a low score of 35, in the individualism dimension. This indicates the behaviour of everyone taking care of each other in the community. Then again the very low score in masculinity indicates a feminine society (Masculine culture is focused on values such as money, success and competition (for dominance and power) whereas feminine society is focused on being supportive, caring and leadership oriented.[14]

With a score of 45 Sri Lanka does not indicate a strong preference in the uncertainty avoidance dimension. Which means that the drive for long term oriented decision making and work is low.

In overall these dimensions indicate the strong connectivity between people and community where they intend to be a highly hierarchical collectivist society. This behaviour defines the gap of which external organizations commencing and operating.

2. Humanitarian involvement in disaster management

Since the 1950s, the frequency of either natural or man-made hazards has increased exponentially and the capability position issue has become the desired tactic for coordinating with emergency humanitarian logistical complications. To overcome this challenge, a precise process and an experiential process have been pooled as the key method to solving this delinquent is proposed by Chawis et al., 2017.

The Chawis et al., 2017 demeanours a survey on the capability location problems that are connected to emergency humanitarian logistics built on both data displaying types and problem types and inspect the pre- and post-disaster situations with admiration to facility location, such as the location of delivery centres, warehouses, shelters, debris elimination sites and health centres. Where an algorithm developed to improve the humanitarian logistical support. The survey examined the four key problems: deterministic capacity location difficulties, dynamic capacity location difficulties, stochastic capacity location difficulties, and robust capacity location difficulties. For each difficulty, facility location type, data demonstrating type, disaster type, conclusions, purposes, constraints, and solution methods were evaluated and real-world applications and case studies offered.

Cavdur et al., 2016 measured the problem of brief disaster response facility portion for temporary or short-term disaster relief processes, propose a solution approach and demonstrate it with an earthquake case study in Turkey. A two-stage stochastic platform is established for the solution of the problem to minimize the total distance travelled, the unmet

claim and the total number of facilities (bearing in mind the potential problems to contact the facilities), where facility apportionment and provision conclusions are performed in the first and second stages, correspondingly [87]. An earthquake case study established by the Prime Ministry Disaster and Emergency Management Authority (typically mentioned as AFAD in Turkey) was used to test their prototype. They castoff five different situations, each demonstrating a dissimilar after-disaster state (i.e. time, traffic conditions etc.), with its specific probability of occurrence, to model the mandate uncertainty for relief supplies. They first solved the deterministic model for each scenario, and then, the equivalent stochastic program. In addition to the demarcated objectives of the model, the quality of each solution was analysed in terms of mediocre walking distance, demand fulfilment rate and average facility consumption.

As per S. Rajakaruna (2017), logistic skills (the ability to arrange and deliver necessary requirements) are a basic requirement for employment and career development within the Humanitarian Logistics (HL) field. These skills requirements are changing in various logistics functions, groups and cultures. At the same stretch increasing global disasters are adding to the challenges that are adversely affecting the HL supply chain. Skills of the logisticians are therefore a necessity to effectively accomplish the supply chain in a disaster [88]. In the Sri Lankan context it is vital to study in to the area of HL, considering the issues such as unplanned relief distribution, Organizational coordination gaps that are being met afterwards the disasters. A number of researches have been carried out in finding skills of the humanitarian logisticians at global level. However, to date there has been narrow discussion on the abilities of humanitarian logisticians in the Sri Lankan humanitarian arena. In their research a Factor Analysis (FA) was directed in order to find the skills of humanitarian logisticians in Sri Lanka. Skills which were recognized earlier by researchers were additionally tested in order to find the applicability in the local HL scenery and identified deferent set of component than in the earlier studies. Results will assist the training and employing humanitarian logisticians.

As Hofstde insights highlight the collectivistic society is one parameter that naturally leads Sri Lankans to assist their fellow community in case of any emergency. Therefore, every time a disaster hits, during the emergency management phase community naturally depends on each other to overcome their difficulties. Also on contrast during the expecting government to intervene during the disaster recovery phase. It is essential to check whether this nature captured in the policy making and enough assistance is provided. Also assessing the efficiency of this mechanism is also investigated during this research.

The researchers over the years had worked on analysing the necessary skills required to humanitarian assistance and it is found out that the logistical support and coordinating as crucial components. Also the maximum use of resources at dire time are still a research area many scientists are interested on.

3. Disaster Management Frameworks of Sri Lanka

There are a number of policies and legal frameworks that defines and facilitates the disaster management of Sri Lanka, which has been developed in the following sequence.

- Reconstruction and Rehabilitation Fund Act, No. 48 of 1993: Used to provide relief to persons affected, reconstruct of property and for rehabilitation.
- Disaster Management Act No. 13 of 2005: provides the institutional structure and governs the disaster management structure. And also defines the National Council for Disaster Management (NCDM) and Disaster Management Centre (DMC).
- National Disaster Management Policy: prepared in 2010 according to the Hyogo framework for action.
- Ministry of Finance and Planning – Budget Circulars No. 152 (I) (II) and (III): Issued in 2013 and 2014: to mitigate the duplication of funding.
- National Disaster Management Plan: prepared for 2013-2015. Provides guidance to the formulation of the disaster management plans in all levels of administration.
- National Emergency Operations Plan: Provides guidelines for emergency preparedness (2015)
- Sri Lanka Comprehensive Disaster Management Programme: The action plan for 2014-2018
- National Adaptation Plan for Climate Change Impacts of Sri Lanka: is prepared for 2018-2025 in line with United Nations Framework on Climate Change.
- Sri Lanka Disaster Management Plan: prepared in accordance with Sendai Framework for the years 2018-2030. [32] [33]

The National Council for Disaster Management was established as the supreme body for disaster management in Sri Lanka which was mandated from the 2005 Sri Lanka Disaster Management act.

ORGANIZATIONAL STRUCTURE
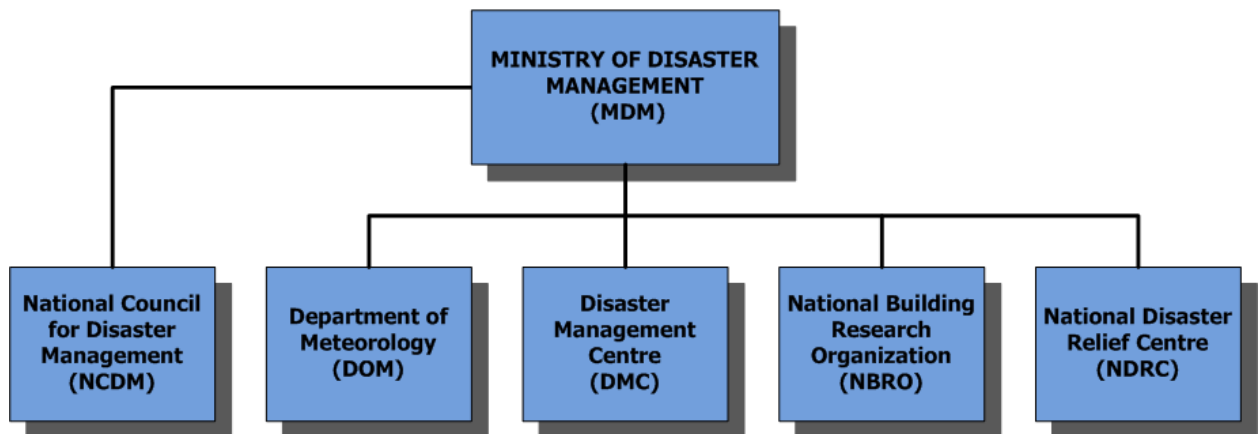
Figure 2 Upstream institutional structure of the disaster management in Sri Lanka
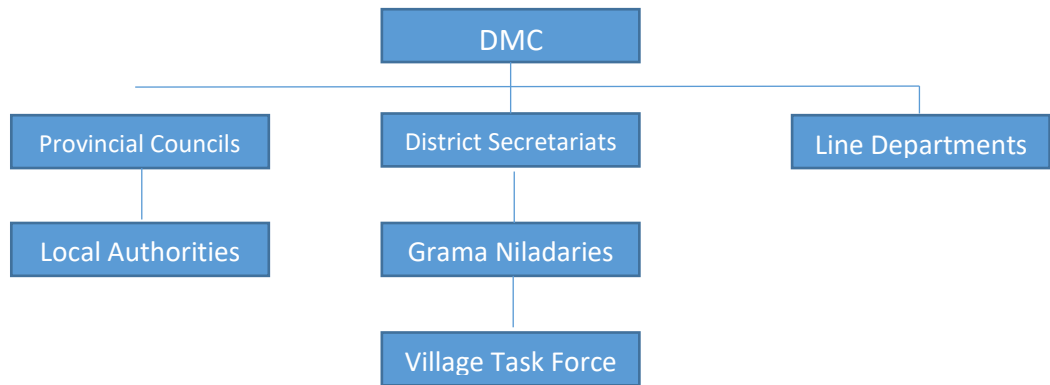
Figure 3 DMC onwards disaster management structure in Sri Lanka

It is clear that all of the policies and the procedures for disaster management are defined at national level and in the decision-making level. There are other elements in the disaster management mechanism such as voluntary organizations and external organizations. The monitoring and level of space given for these organizations are a gap generated from this review. Identifying the ground level operational effectiveness of these policies with all the stakeholders including external organizations is what comprehensively evaluated from the research.

Shehara et al., 2019 conducted a research using Social Network Analysis theory identified the stakeholder behaviour of Disaster Management (figure 4). Furthermore, overall policies and institutional structures indicates the centralized, umbrella behaviour of the disaster management framework (Shehara et al., 2019). The affected community urge for government to do the necessary and required work in disaster mitigation and recovery comes as an output of this mechanism.
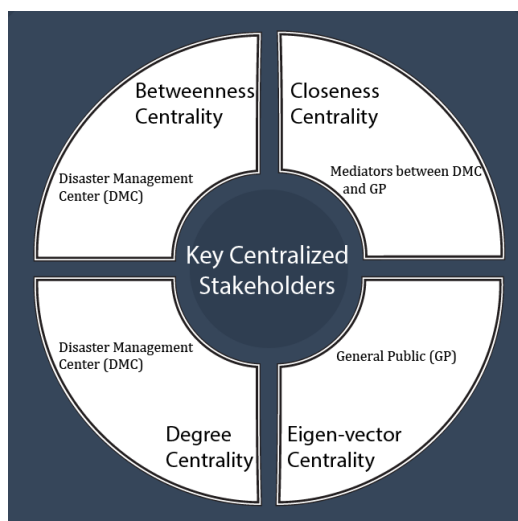
Figure 4 Key Centralized stakeholders - Source**:** [43]

4. Involvement of External Organizations in Disaster Management

In this context with policies and the behavior of the culture and society, it is now looked at how external organizations function in the practical scenario. Following are some key external organizations function in the grass root level in Disaster Management mechanism. One of the outputs observed from the cultural behaviors categorized about Sri Lanka is the "Shramadana". [44] The "Shramadana" is a cultural social activity where people freely contribute the man power for a public purpose. "Sarvodaya" is an organization where this concept of "Shramadana" was structured and institutionalized for better use by Dr. A.T. Ariyaratne as a "Sarvodaya Shramadana" Movement of Sri Lanka. He conducted the first "shramadana" work camp in 1958. As of today "Sarvodaya" is the largest non-governmental, locally founded organization in Sri Lanka. National and international donations, as well as partnership of the organization, are invested in three avenues. Growth and Development, Well trained workforce and emergency relief. [45] Next to these well-established organizations are the organizations that started from the youth generation of Sri Lanka.

International Movement for Community Development (IMCD) is one organization of such, where locally founded and now expanded internationally as well. IMCD works as a social service organization which is formed from alliance of youth. The organization as of today worked with 1200 volunteers, conducted 85 events and has direct beneficiaries of over 74,000. This work was all carried with the collaborations from over 74.000 donors. External organizations do involve corporate sector as well. [46]

There are number of corporate business giants involved in the disaster management. [47], [48] Mass media operators, network providers and apparel manufactures who contribute as a corporate social responsibility. Mass media tend to launch relief aid programs. It is observed in Sri Lanka how community tend to contribute in any possible level for these relief aid programs. Other than to these relief aids the involvement from the corporate sector do involve in risk reduction activities as well. Dialog is one organization as such, where they contribute with research activities. Dialog is one of leading mobile network providers in Sri Lanka. When it comes to DRR activities, one of the community investments from Dialog mobile is the DEWN app. [49] The Disaster Management Center (DMC) together with Dialog launched the Disaster Emergency Warning Network (DEWN). It is the first mobile based disaster alert mechanism of Sri Lanka. It is an ongoing collaborative development with University of Moratuwa. [43]

Other part of these external organizations are the international donor agencies such as Asian Development Bank (ADB), International Monitory fund and World Bank. Furthermore international Red Cross also function in the grass root level addressing the needs of the community. Their contribution is varies from monetary support, expertise support and aids support. That gives an overall view on external organizations' operation in Sri Lanka, how they have evolved and major areas the external organizations involved in. [50]

5. Questionnaire Survey Development

An assessment framework was developed in the form of a questionnaire survey as an evaluation framework to access the effectiveness of the disaster management framework. The evaluation framework has the preliminary structure as shown in Table 1. The framework was initially prepared to evaluate the disaster management process effectiveness in floods in Kalutara. The framework is used then in different case studies and validated [35]. The disasters were initially staged in to the three stages of a disaster; Disaster Risk Reduction (DRR) stage, emergency response stage and recovery stage [37]. At the same time, facts which serve as the fulfilment criteria of a given stage were identified. Yet the facts are not tangible enough, hence for each factor relevant attributes were defined. Data collected were back calculated using a weighted way in to the three preliminary stages. In the results analysis it is discussed how with and without the external organizations the disaster management process operates in the form of effectiveness. Each attribute generates a tangible dimension for the facts mentioned here. From overall data the effectiveness of each fact as well as effectiveness in the stage is calculated.

Table 1 Evaluation Framework to access the effectiveness of disaster management framework

Stage	Fact	Attribute
DRR Stage	1.Early Warning	Time
		Mode
		Reliability
		Accuracy
	2.Information Availability	Past data

			Geological knowledge
			Geological knowledge
			Physical structure
			Economic knowledge
			Health knowledge
	3. Capacity Building		Activities
			Physical
			Development
			Exposure
Emergency Response Stage	4.Evacuation		Necessity
			Time
			Assistance
	5.Search and Rescue		Requirement
			Involvement
			Time
	6.Leadership and Coordination		CBOs
			Community leader
			Guidance
	7.Provision of Humanitarian Assistance		Involvement
			Effectiveness
	8.Initial Damage and Needs Assessment		Checking
			Effectiveness
Recovery Stage	9.Provision of Early Recovery Assistance		Financial
			Knowledge
	10.Temporary accommodation and repair		Requirement
			Fulfillment
	11.Rebuilding Houses and Buildings		Time
			Money
	12.Restoration of Infrastructural Services		Water
			Electricity
			Accessibility
	13.Re-establishment of Sustainable Livelihoods		Economic
			Human
			Physical

METHODOLOGY AND CONTEXT

The study was structured (figure 6) initially to identify the disaster management processes, legal frameworks, institutional involvement and impactful parameters with respect to floods, via a desk study based literature review.

Then with a questionnaire directed to the bottom level affected people data were collected to measure the effectiveness of governmental and non-governmental organizations in flood. Finally data acquired were analysed to understand context of external organizations in flood.
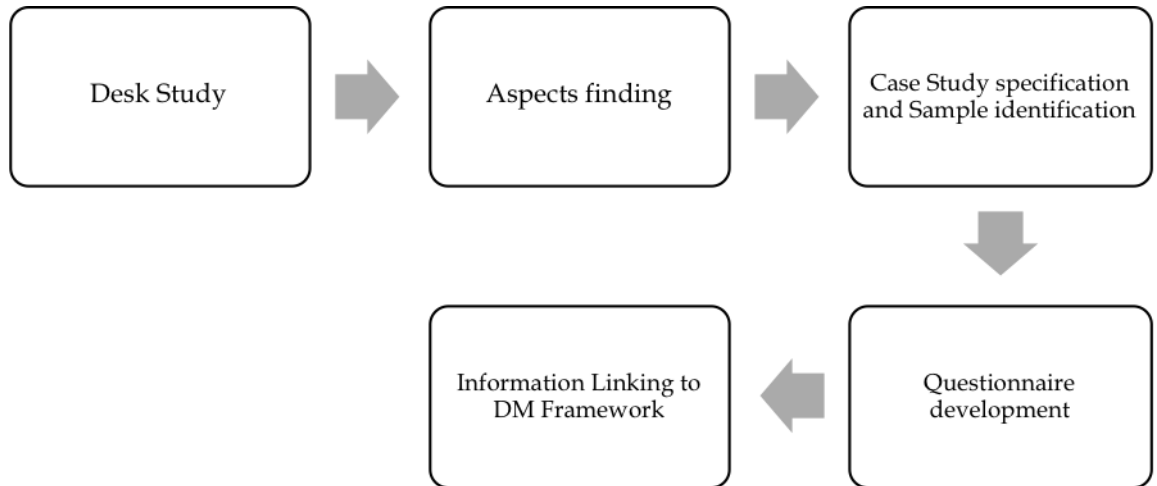
Figure 6 Methodology of the research work

As mentioned in the introduction since the year 2015 Sri Lanka has experienced flooding around May every year, with the southern coastal line being the most affected area. For this study, the aforementioned scenario was focused on.

Total affected people from the years 2016 and 2017 compared for further analysis in this section.. When comparing this with the situation report of 2018 May flood as of 10th July 2018 the total affected people reported by DMC is 338,396. The affected total from years 2016 and 2017 are accumulative of every disaster including the floods, landslides whereas the affected total of 2018 is only from the May floods of that year. Here it is observable information is that a decline in the total affected community of the May floods do not have a decline. This is the context of May flood influence and overall impact currently.

For administrative purposes Sri Lanka have divided into 9 provinces, and each of these province consists of few districts and in overall there are 25 districts. With the understanding on the behavior pattern of the May flood recently, it is possible identifying the specific impact of this scenario towards the Western province of Sri Lanka where the province was chosen as the primary province of the case study.
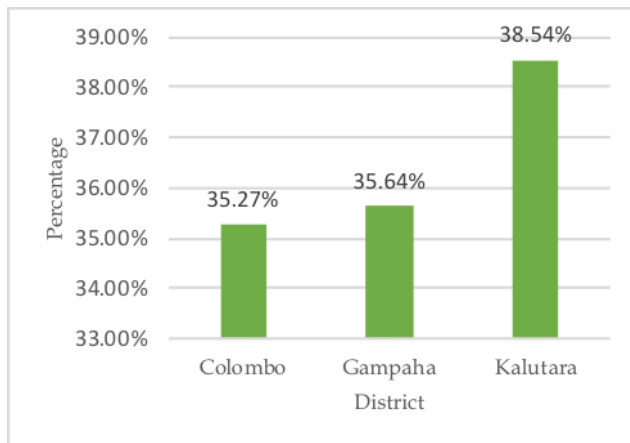
Figure 7 Vulnerable population percentages of Colombo, Gampaha and Kalutara districts of Sri Lanka

Figure 7 illustrates the population diversity of three districts in Western province. Here the vulnerability population of each district was processed, where categorization was done using age limits, under 14 and above 60 years of age.

From this it was perceived that most vulnerable community proportion is from Kalutara district (38.54%). Hence Kalutara district was chosen form Western province for the case study. Figure 9 illustrates the impact in terms of the proportions of the affected population to the total population during May 2018 flood in Kaluatara district based on the administrative unit District Secretariat (DS) divisions.
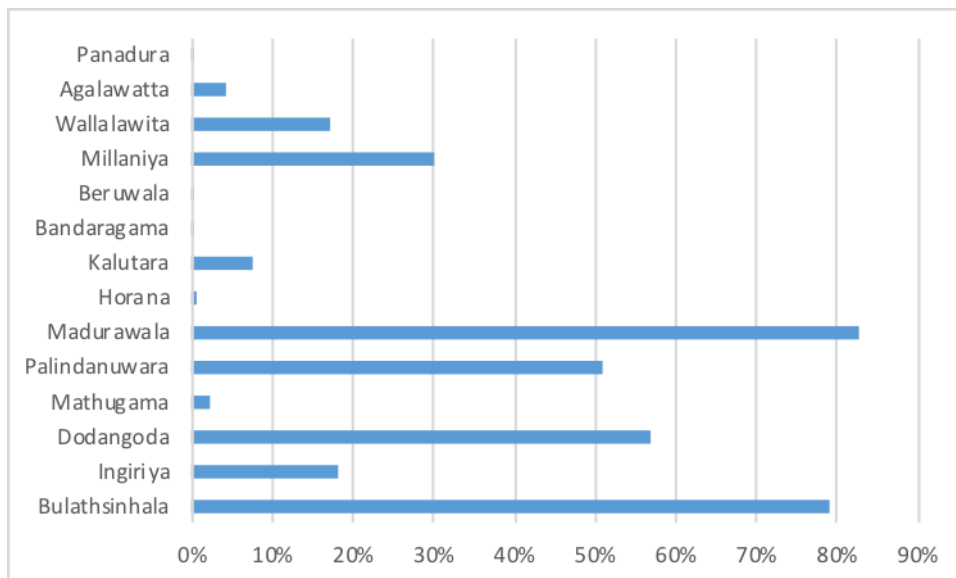
Figure 8 Percentages of affected population from total population in each DS division of Kalutara District

As indicated in figure 8, Madurwala, Palindanuwara, Dodangoda and Bulathsinhala DS division percentages are above 50%. Hence the research exertion was focused on those DS

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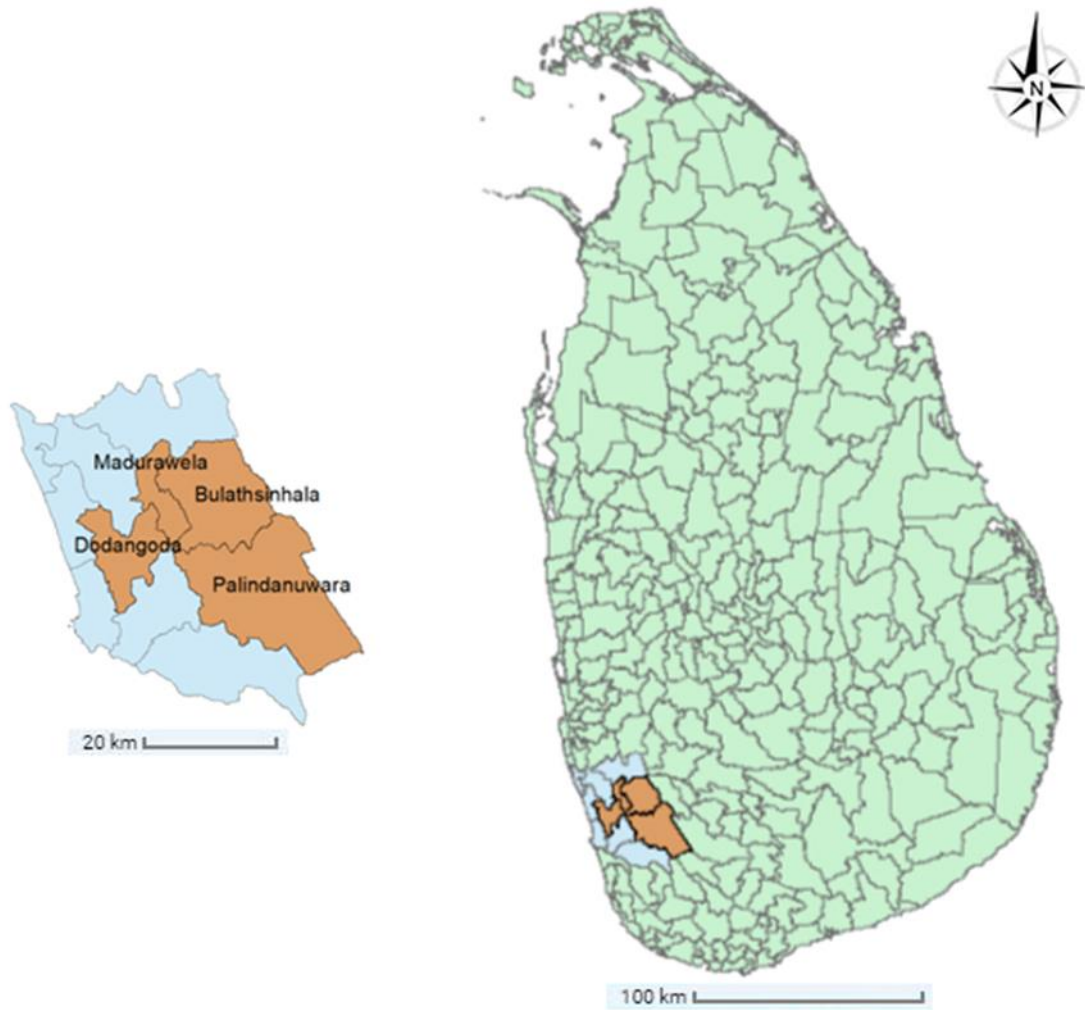
divisions as indicated in the figure 9. Whereas from each division 40 responses (Flood affected) were collected.

Figure 9 Sri Lanka and locations of the Survey – The focused DS divisions

All of the respondents are affected community and within them were two governing officers as well. Other than that there were police officers, farmers, businessmen and day workers.

RESULTS

As mentioned in the introduction external organizations are outside organizations, which involves in to the system when it is disturbed. In this case study there are four areas where the external organizations do use as grounds to engage in to the disturbed system. Namely provision of humanitarian assistance (emergency aids providence especially), early recovery assistance, search and rescue, and evacuation. The data were then evaluated to identify the

governmental and external organizations effectiveness as well as the overall humanitarian involvement in each phase of disaster.

For the latter it was evaluated for two scenarios, with the involvement from external organizations and without the involvement form external organizations.

In following four sections it is described the parameters used in evaluating the four areas where the external organizations do involve in during the disaster.

1) Provision of Humanitarian assistance

This value was generated from the responses to following questions,
- Did any NGO, GO help you get provisions during the flood?
- Provisions you received were, Not enough/ Enough/ Too much?

Involvement and the effectiveness of the provided support were used as parameters to calculate the effectiveness of 93%. The effectiveness of the support provided was evaluated tangibly using the satisfactory providence of the provisions.

Red Cross and "Sarvodaya" are two main non – governmental organizations which provided the humanitarian assistance and aid. Also as mentioned in the background mass media operators too involved in to the system in case study area. The system found to be approached by these external organizations and volunteers do tend to stay at the affected areas. Yet the highlighted and impactful contribution was from the aids coordinated from District Secretariat office. In the case study incidents, effort was put to combine the work of all the organizations in humanitarian assistance. This results indicates that the external organizations such as Community based organizations has a higher level of interaction with the grass root level community in distributing aids and has very little to no interaction in decision making level to coordinate the aids. Also the government do has the highest level of interactions in the decision making level as well has the systems to interact in the grass root level as well to distribute aids. These observation are used to develop the conceptual illustration (figure 12) on the context of people and institutional behavior.

2) Evacuation

External organizations do involve in this area entirely when the system do not possess resources or systems to evacuate by itself from the disaster. As indicated in table 1 evacuation was evaluated using three parameters, the necessity, assistance providence and time took for the evacuation. Here also the external organizations are the main contributor in assistance with their naturally generated assistance from voluntarily groups.

From the survey it was identified that 40% of the community received the early warning and yet 74% of them had the actual need to evacuate from their home. But it was 26% of the needed community was able to evacuate with enough lead time. This phenomena mainly occurred since it was a flash flood.

3) Provision of early recovery assistance

The financial support and the knowledge support were the two direct aspects measured from the early recovery assistance. It was measured with respect to whether the support was provided if so by which institution. External organizations do extend the support in various dimensions in this area. From cleaning houses, wells to providing medical and other necessary support to camps were coordinated with external organizations. It was evident in this area too that the external organizations has the highest level of interaction in the grass root level and in national of decision making level they poses minimum influence. Hence it was the government that generated the coordination activities and allocated the recovery assistance provided by external organizations. One qualitative highlighted from this section of the survey is the DS office involvement. From "Grama Niladhari" (Village officer) level, initiation of the work and overall delegation of the funds and distribution happened.

There the overall effectiveness, form both governmental and external organization coordinated assistance was 89%. This value indicates the provided support satisfactory level as measured from the beneficiary overview. This high effectiveness is processed outcome from the united work of external organizations and government organizations.

4) Search and rescue

Similar to evacuation when the system do not possess resources for search and rescue activities external organizations do involve. Search and rescue was evaluated using requirement, involvement and the time taken. It was naval forces came to assist the system in search and rescue activities. One observation from this phenomena is that there are external organization who do have influence in decision making level.

With the understanding on external organizations involvement and effectiveness from above four sections, the survey results were then analyzed to identify where government organizations do operate on as well as to summarize the external organizations involvement.

5) Effectiveness of the Government Organizations and External Organizations involvement

There are three major numerical results from the survey about the government involvement in the disaster management process. It was government officials who conducted the post disaster evaluation. From the survey it was identified that overall 81% from the affected community was evaluated for damages by the government officials. Yet it was 43% that was followed up and from them 86% was received compensation. The compensations were mainly for household repairs.
Above three are the main facts on evaluating the GO involvement after the floods, when it comes to DRR activities, it's averaged around 35%. Hence it is observed that the government involvement is imbalanced towards the latter part of the disaster management process. In this scenario government act as a facilitator for the system to calm down and achieve its undisturbed state.

Where as in the non-governmental and external organization involvement is more imbalanced towards the emergency response stage.

6) Effectiveness of humanitarian involvement in each phase

The overall effectiveness of each stage management in the case study was recorded and calculated as follows. As declared in the background under questionnaire survey development of the survey, each stage has facts to record the insights of each stage and attributes of each fact was used to generate a tangible quantitative record. From the records reserved a weightage was prearranged and analyzed to generate the following effectiveness figures for each stage.

- DRR Stage: 45%
- Emergency Response stage: 59%
- Recovery stage: 51%

The results analysis was further carried out in number of scenarios, where different facts contributing to the overall effectiveness was removed from the data (where the hypothesis was to check the system behavior without the selected factor). When the external organization involvement factor was detached from the data following effectiveness figures for each stage was generated.

- DRR Stage: 45.5%
- Emergency Response Stage: 27%
- Recovery Stage: 42%

Associating the above numerals following figure 11 was generated.
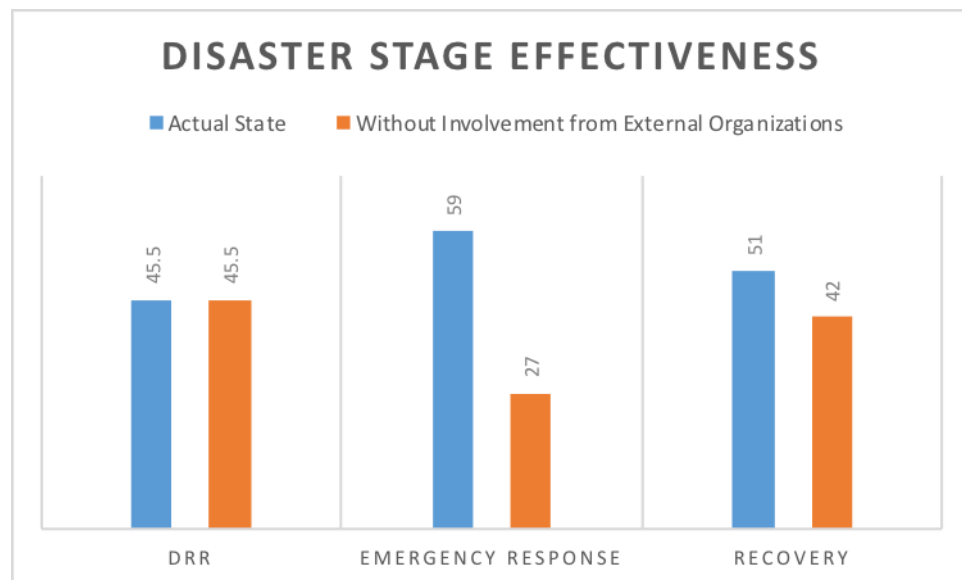
Figure 10 Disaster Stage effectiveness (actual stage vs without the involvement from external organizations)

The overall effectiveness of the emergency response stage drops down from 59% to 27% when the external organization factor is removed from the data. Whereas in DRR stage it remnants same and in recovery stage it drops down from 51% to 42% as illustrated from the figure 10.

In emergency stage all the primary facts (Evacuation, Search and rescue, Leadership and coordination, provision of humanitarian assistance) except Initial needs and damage assessment had involvement from external organizations. Hence, a drop in each primary fact was observed. In overall emergency response stage an effectiveness was dropped from 59% to 27% by 32% when the external organizations were removed from data. This illustrates the level of impact from external organizations in emergency response stage. Emergency response stage would be again having a lower effectiveness (less that the other two stages) if not for the contribution from external organizations.

For recovery stage the reason behind the drop entirely depends on the fact of provision for early recovery assistance. There government organizations and external organizations support and contribute in the same level. Hence when the external organization fact removed the overall value for recovery stage dropped from 9%.

FINDINGS

There are two major finding from the research work, one being the conceptual illustration of the people institutional behavior and other is the effectiveness of external organizations in the disaster management process at Sri Lanka.

Following conceptual illustration (Figure 12) indicates the context of people and institutional behavior and relations. As mentioned in the background the Hofstede – insights on Sri Lanka was used in developing the Illustration.

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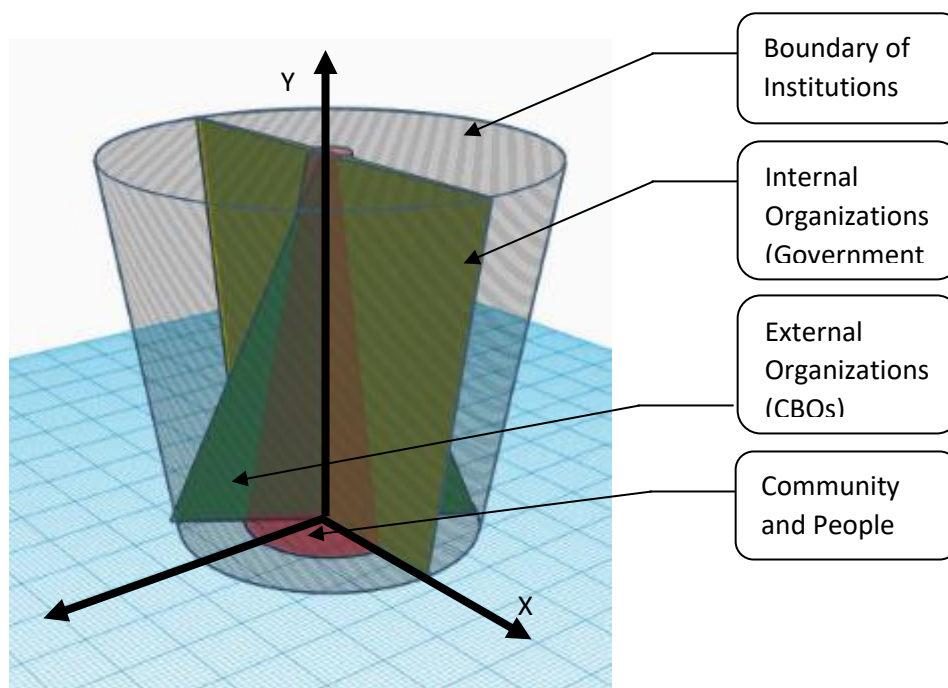
Figure 11 People and Institutional Behavior and Relations

In the figure 11, X axis indicates the level of interactions, X-Z area ratio indicates the human institutional power delegation (in the top higher institutional area and lower human area shows minimum power delegation), Y axis indicates the level of influence/power and the red color cone indicates people whereas the outer transparent cone indicates boundary of Institutions. The slices (Green, Yellow) indicates organizations, Green – community based organizations, Yellow - Government and governmental organizations. The width of a slice defines the level of interactions with the people from that level. As discussed in the results the illustration stage the nature of behavior in external and government organizations.

Government do have the highest level of interactions and influence from the people up the hierarchy, whereas for community driven organizations the highest level of contribution comes from the bottom part of the people hierarchy. If we take a community based voluntarily group like IMCD, they do have the highest level of interactions with the grass root level. Whereas their interactions with the decision making bodies is minimum. Same time people who lays in the higher level of influence gets decreased along the Y axis.

Likewise the diagram can be used to understand the level of networking and the nature of coordination required among institutions, and institution – human (HI and II).

Up next to the above finding is the effectiveness of external organizations. It was found that the higher effectiveness in emergency response stage is due to the external organizations in Sri Lanka. As illustrates in the results and from the effectiveness analysis calculation it is evident that the involvement of the external organizations are focused on the emergency response stage. As [35], previously stated, Sri Lankan disaster management process has its highest effectiveness in the emergency response stage. Hence it is evident that the higher effectiveness in the emergency response stage of Sri Lanka is due to the external organizations.

CONCLUSIONS
1) Administrative oriented disaster management system.
It was well observed with all the policies that the defined processes are there from the administrative sector for disaster management. Yet the involvement of undefined parties during disaster makes the system disturbed. These parties include but not limited to non-governmental organizations, voluntary organizations and forces and also the political interference.

2) The involvement of the external organizations are focused on the emergency response stage.
The activity frequency on disaster management from organizations such as Red Cross, Sarvodaya, Military tri forces and the involvement of media increases in relief services providing. The Sri Lankan cultural behavior which was discussed in the background using the

Hofstede insights illustrates the defining factors of external organizations (volunteers and community based organizations etc.) The links, correlations and networks between external organizations, internal organizations and community are illustrated in the graphic in findings. This finding illustrates the grass root level impact generates from the external organizations.

3) Community trust in external organizations (especially in early warning dissemination)
Above is a question mark ahead of the structure with the complications in all the networking. A number of organizations involved being high, people depend on various platforms to receive information, platform accuracy are areas found to be clear.

4) External organization empowerment and inclusion in disaster risk reduction activities can be improved.
It is clear with the results that, it is hard to find mechanisms for organizations outside of the government to involve in long term capacity development activities. Long term policy is not very clear in this aspect.

5) Recent development and growth in research work in the area.
Recent research work from the University of Moratuwa and the University of Peradeniya through EU Erasmus+ funded project "CApacity Building in Asia for Resilience EducaTion" on improving the evacuation planning, early warning dissemination and public private partnerships make a positive contribution on opening dialogues in enhancing the coordination of external organizations work in disaster management.

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Evaluation of Multi-Hazard Early Warning Systems (MHEWS): Case studies in Myanmar, and Sri Lanka

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1.1   **Abstract**. This paper is based on data collected from the 2004 Tsunami disaster event and analyses the availability of Early Warning Systems in Sri Lanka and Myanmar after 15 years. An evaluation framework in the form of questionnaire survey was developed through a thorough literature review and studying the existing frameworks of both countries. Same questionnaire survey was used to gather information from two communities in Myanmar and Sri Lanka each to understand the existing MHEWS and preferred warning systems. Subject experts were interviewed to verify the information gathered. When analysing the data, an index was developed with parameters of accessibility and preference. The early warning systems were indexed and further analysed in both countries in a comparative manner. The observations indicate the use of early warning towers is very efficient in Sri Lanka whereas TV/Radio has a higher efficiency as early warning system in Myanmar. There are gaps observed in the disaster management mechanism of Sri Lanka and Myanmar during the survey. Specifically in the early warning systems there were gaps identified in terms of technology usage, coverage as well as trust and reliability of warning dissemination which required resource allocation and development.

Introduction

According to the United States Geological survey, the world's fourth largest quake since 1900, impacted Southern Asia on 26th December 2004 unleashing a tsunami that crashed into India, Indonesia, Malaysia, the Maldives, Myanmar, Somalia, Sri Lanka, Thailand, Bangladesh, South Africa, Madagascar, Kenya, Tanzania and the Seychelles. The earthquake had a recorded magnitude of 9.1, origin at coast of Northern Sumatra (3.295°N 95.982°E) with a depth of 30km on December 26th, [89].

After the disaster on 2004, affected countries started investing and developing on Disaster Risk Reduction activities. Early warning is an important part of the DRR activities, where the casualty numbers and damages could have been much lower if proper early warnings were

issued. With this understanding the developments on early warning systems were implemented. The developments on early warning systems are not only limited on to Tsunami. The systems are evolved in to multi hazard early warning systems. The paper compares the early warning methods available and the people preference over those early warning methods. The early warning systems development, data accessibility as well as the cultural context, coastal population vulnerability context are found to be of similar and comparable in Sri Lanka and Myanmar. Hence Sri Lanka and Myanmar are two country case studies used where the data were gathered from a scientific research work conducted.

Sri Lanka and Myanmar consists of masculine, collectivist culture [42]. This indicates the behaviour of everyone taking responsibility for each other in the community as well as the dependency of a leader to drive in situations. Theravada Buddhism drives and impacts highly on the cultural attributes in Sri Lanka and Myanmar. Also a high power distance is observed in both countries [15]. This governance level behaviour impacts on the disaster management mechanism in both countries.

Natural hazard maps of Sri Lanka and Myanmar and Sri Lanka has similar readings. Where floods, Cyclones and Droughts are natural hazards present. The highly impacted disaster common for both the countries is the 2004 Tsunami. The coastal regions of Sri Lanka and Myanmar are most vulnerable to natural hazards. Because coasts are amongst the most dynamic environments on Earth. The coastal population regions in Sri Lanka and Myanmar have a history of adapting to environmental change and local sea-level rise.[16]

Myanmar has a total population of 59,094,870 where the coastal population is 1,544,000 [90]. The country has total coastline of 1930 Km [91]. Sri Lanka has a total population of 21,336,833 with a coastal population of 4,355,000 [90]. The island has a total coastal length of 1340 Km [91].

Until 2004 Sri Lanka had very little experience on Tsunamis. According to the historical records the only known is the historical legend of Princess Viharamaha Devi sacrificed to the sea to prevent inundation of the land by sea probably due to a tsunami event in 200 BC [92]. It was after the 2004 Tsunami Sri Lanka implemented policies and started working on the technologies related to Tsunami early warning and risk reduction activities [93].

In Sri Lanka the 2004 tsunami struck a relatively thin but long coastal area stretching over 1,000 kilometers, or two thirds of the country's coastline. [94] There were 13391 deaths and 699 were missing people were recorded in Sri Lanka. From 25 Districts in Sri Lanka, 9 districts had casualties. [95].

When it comes to Myanmar, during the known history Myanmar had experience Tsunami in 1714, 1750, 1930 and in 2004 [96]. The impact data from 1930 and 2004 were only publically available. The deaths recorded from the 1930 and 2004 incidents are 500 and 150 respectively. [97]. At Myanmar there were 22 majorly affected localities from the 2004 Tsunami situated in Ayeyarwaddy Delta, Dawei Area, Myeik Area, and Kawthaung Area. [98]

In Sri Lanka and Myanmar there were number of changes made to the disaster management mechanism after the 2004 Tsunami. In Sri Lanka the Disaster Management Center is the focal point in disaster management whereas National Council for Disaster Management act as the emergency governing body where the president of the country act as the chairman. When it comes to Myanmar there are twelve working committees to govern the disaster management process.[99], [85], [100] Where each of the administrative level has working committees. These were observed during the institutional survey conducted parallel to the community survey as mentioned in the methodology of this paper.

With improvements in the disaster management mechanisms, there were developments in the early warning systems as well in both countries. Even though it was since more than a decade to the date the developments need to be evaluated with respect to the effectiveness in order to be better prepared. This paper identifies the community level early warning mechanism usage and recommend on areas to improve.

Methodology

In order to gather data case studies were conducted as research surveys. The agenda and basic framework of the research surveys conducted at Sri Lanka and Myanmar were similar. The Programme was conducted at two selected communities from each country. In Sri Lanka it was Wattegama South and Dodampahala East division of Dickwella, Matara (Figure 1). The communities are located in the southern part of the country with fishing is the common income method. In Myanmar it was Bu Gwe Gyi Village and Thazin Village, in Pathein District (Figure 2). The two communities are surrounded by fishery and prawn farms.
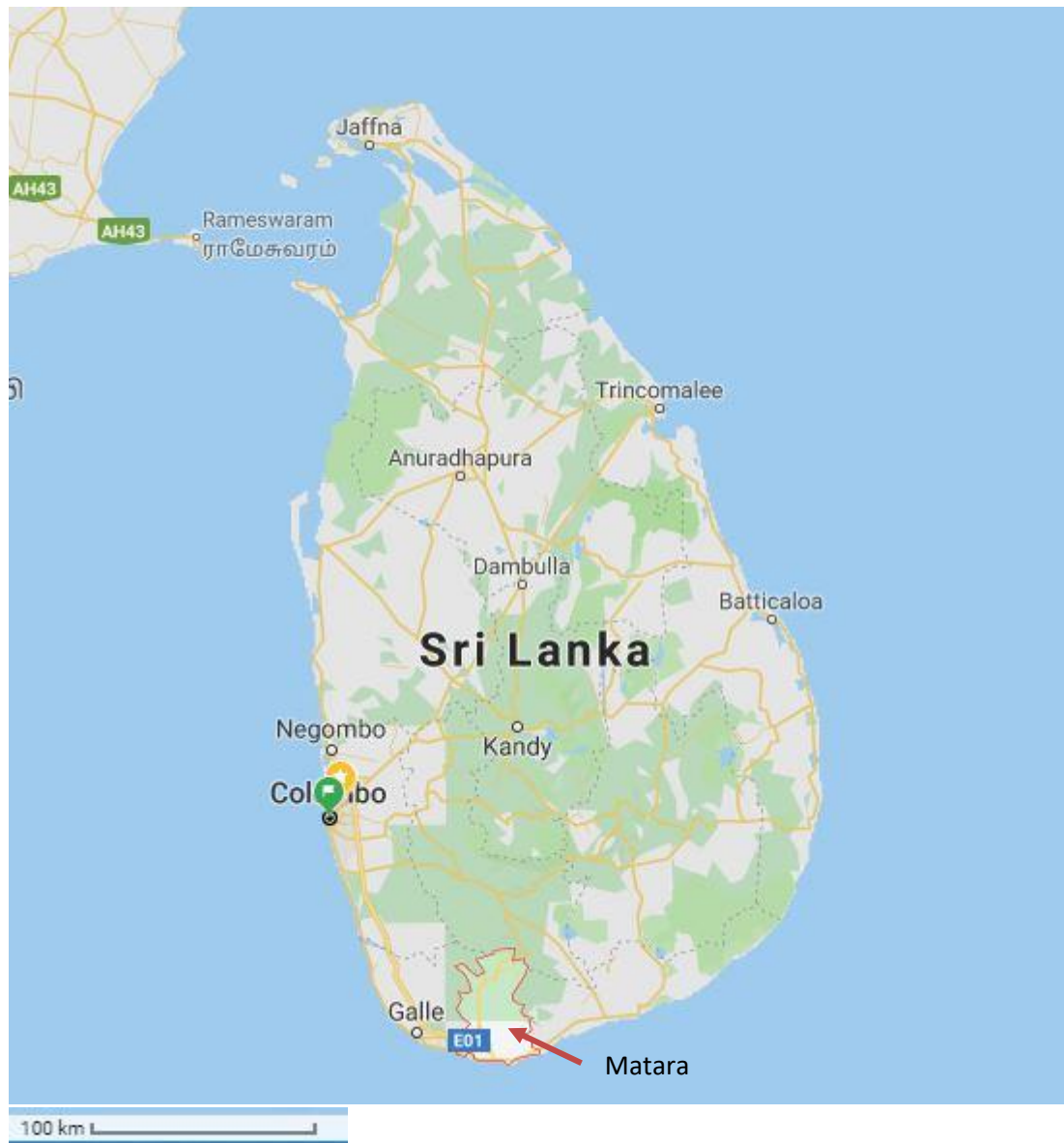
Figure 1: Matara District of Sri Lanka

Figure 2: Pathein District of Myanmar

The data were collected using a survey framework developed to evaluate the effectiveness and efficiency of a disaster management mechanism. The survey was constructed on three stages; disaster risk reduction stage, emergency response stage and recovery stage. For each stage there were facts and for each fact tangible attributes were defined in evaluating [52]. At each community the data collection had two parts.

First part of the data collection was from a target group discussion. Government official responsible for the community coordinated the discussion. The target group profiles were elderly people from the community and community leaders whom had the experience of the tsunami event and were part of the disaster management mechanism in community level. The discussions had the objective of understanding the mechanism of disaster management process. Second part of the data collection was the individual survey. The survey team visited the affected community houses under the guidance from community leaders and collected data

At Sri Lanka 41 responses (All of them were affected from 2004 Tsunami, where 55% were fishermen, 28% were farmers and 17% were others) were recorded and at Myanmar 39 responses (Where 42% were farmers, 39 % were fishermen and 19% were others are the profiles of the respondents.) were recorded.

General Observations

Availability of different early warning systems in each country (Availability was observed) was accessed from literature and previous data available.

Large number of early warning methods were checked for the availability of the MHEWs. From those it was identified that there are 5 early warning systems available in Sri Lanka and Myanmar. The National position papers prepared for Sri Lanka and Myanmar for were referred in identifying the availability and accessibility at each country.

- o Loud Speakers (Where announcements were made using a loud speaker attached to a moving around vehicle)
- o SMS
- o TV/Radio
- o Door to Door
- o Early Warning Towers

These five identified early warning systems are considered for the data observation and analysis in the research work.

Three aspects related to multi hazard early warning were focused and observed during the community surveys at the four community survey sessions.

- General annotations with regard to the early warning systems and related cultural and institutional behaviors.
- Early warning methods community has access to. (Hereon mentioned as the **"Accessibility"**)
- Early warning methods community most likely to respond as per their own preference. (Hereon mentioned as the B **"Preference"**)

General annotations in Sri Lanka

- The Early warning towers had a maximum range of 5km. Hence people living outside of the range could not hear the warning sounds. This was experienced during the evacuation drills.
- Mobile networks do not work properly during cyclones. Hence mobile and internet related warnings do not get disseminated at the time of need.
- TV/Radio signals are not clear during the cyclones and other extreme weather events. Hence community finds it hard to access these modes.
- People had experience on false warnings. Some were generated from community itself. And there was an experience on false Tsunami warning once. Hence community gets reluctant to evacuate during an early warning. [101]
- Community has limited ownership in the disaster management mechanism. [102]

General annotations in Myanmar

- The community has minimum access to electricity. The only available electricity source is from domestic solar panels. Hence the access to TV/Radio and mobile phones is minimum.
- Community has experienced number of false alarms. Even though there are strict regulations to stop such alarms, especially as word of mouth from the community has generated false alarms.
- In the upstream there is a repetition of work from Department of Meteorology and Hydrology and Emergency Operations center of Department of Disaster Management in monitoring, forecasting and disseminating warnings.

During the surveys the respondents were asked to choose all the methods they can receive early warning. Figure 3 illustrates the data comparatively for Sri Lanka and Myanmar. Percentage number illustrates out of all the respondents how many had chosen that early warning method as one of the ways they can receive early warning.
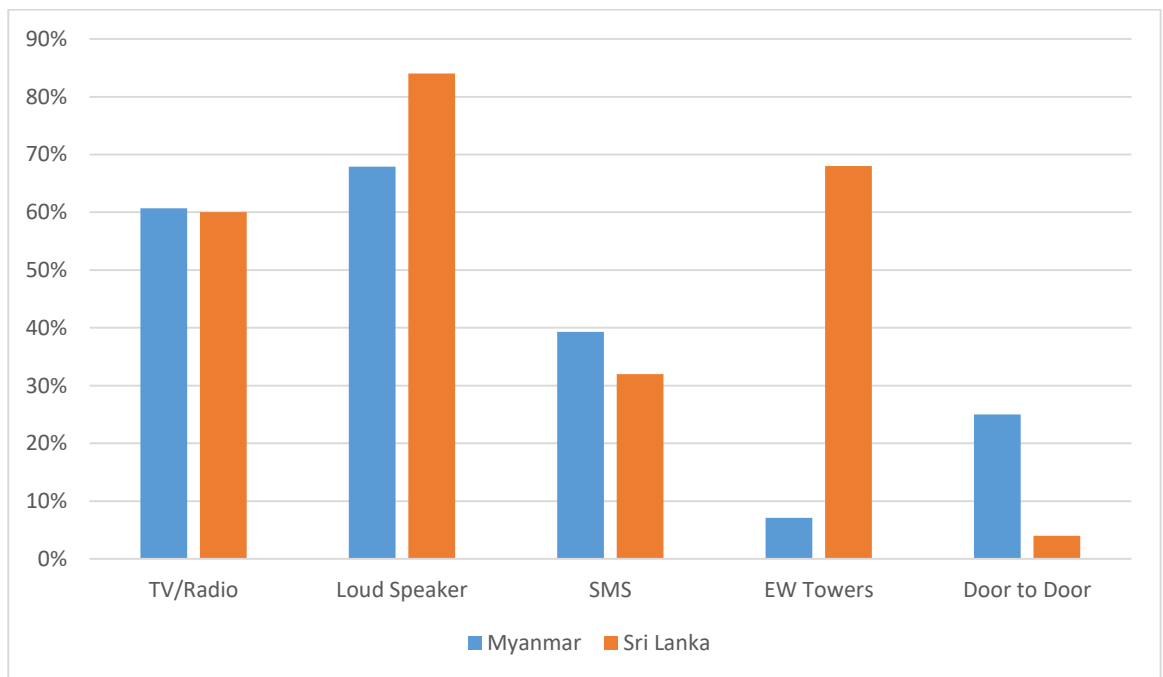
Figure 3: The methods early warning received in Sri Lanka and Myanmar (**"Accessibility"**)

Sri Lanka and Myanmar do have access to loud speaker systems mostly. It is observed that the early warning towers in Myanmar are not developed to the extent of Sri Lanka. Also Myanmar has accessibility to TV/Radio in a similar extent as Sri Lanka, yet it is not reliable given the gap that Myanmar needs development in electricity in communities.

The next data observation is on the preference of the early warning method. The respondents were asked to rate the warning mechanism they are most likely to respond to. A scale of 0 to 5 was used. The figure 4 illustrates the data collected. Total points for a method was divided by the number of respondents to lean the data.
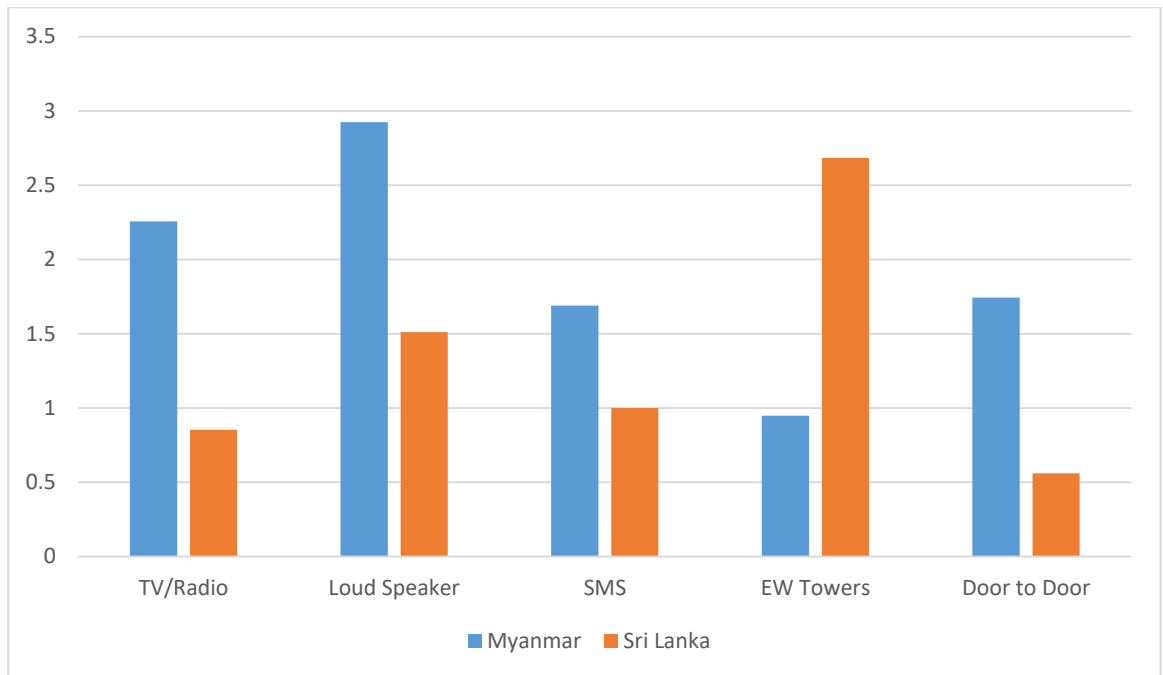
Figure 4: Preference of Early Warning methods in Sri Lanka and Myanmar (**"Preference"**)

Early warning towers has the highest preference in Sri Lanka, where as in Myanmar it is the loud speaker. Door to Door method has a higher preference in Myanmar comparatively.

There are number of gaps observed during the survey. A list down of the identified gaps is provided following section. In the analysis and conclusion the impact from these gaps are too considered.

Analysis

For the analysis of Early warning systems an index named EWI – Early Warning Index, for each early warning method was developed as follows.

EWI = Accessibility Percentage of the Early Warning Method x Preference Points

This index indicates the effectiveness and efficiency of an early warning system. The preference and accessibility parameters are the base of the index. Both the parameters are necessary in evaluating an early warning system. Yet they aren't individually sufficient enough to evaluate. The development of the EWI as well as identifying other parameters can be conducted as an extension of the study.

Table 1: Early Warning Systems index comparison of Sir Lanka and Myanmar

Early Warning Method	Sri Lanka			Myanmar		
	Accessibility	Preference	Index	Accessibility	Preference	Index
TV/Radio	60%	0.85	**0.51**	61%	2.26	**1.38**
Loud Speaker	84%	1.51	**1.27**	68%	2.92	**1.11**
SMS	32%	1	**0.32**	39%	1.69	**0.66**
EW Towers	68%	2.69	**1.83**	7%	0.95	**0.07**
Door to Door	4%	0.56	**0.02**	25%	1.74	**0.44**

In Sri Lanka Loud Speaker and EW towers has indexes over 1. In Myanmar TV/Radio and Loud speaker has indexes over 1. Hence in both countries the loud speakers (A vehicle with a loud speaker on top moving around decimating warnings) has similar and high impact.

With the gaps observed previously it is analyzed that the top indexed Early warning systems has associated barriers in both countries. In Sri Lanka EW towers has the highest index of 1.83. Yet it was observed that the EW towers has a range barrier. The recorded accessibility of 68% was during drills. Which indicates that one third of the community do not heard the warning from EW tower even during the drill. Hence even though people highly preferred (2.69 preference index where the immediate next is 1.51 points with Loud Speaker) practically EW towers has improvements to be made.

Moreover in Myanmar it is TV/Radio has the highest index of 1.38. Yet as discussed in the gaps the communities has barriers in accessing electricity. The recorded 61% of TV/Radio accessibility is from the electricity generated from domestic solar panels. Hence, the reliability of the method is questionable.

Also comparing the index differences for early warning systems EW towers has the highest difference. In Sri Lanka it is 1.83 and in Myanmar it is 0.07. With the 2004 Tsunami experience Sri Lanka has actively made efforts in establishing early warning towers when compares to that of Myanmar. Myanmar do need to further establish early warning towers and develop to improve the accessibility.

The door to door warning dissemination has the lowest index in Sri Lanka with 0.02. Yet in Myanmar it is 0.44. This increment in the door to door method is due to the community ownership in the process of early warning. As mentioned in the gaps Sri Lankan disaster management mechanism has limited coordination with indigenous methods and community owned disaster management mechanisms. In Myanmar the context is completely different where the community has total ownership of the process.

Out of the five early warning systems SMS has lower indexes in both countries, 0.32 in Sri Lanka and 0.66 in Myanmar. The community trust and the reliability of the SMS systems can further improved in both the countries.

Conclusion and Areas to Improve

Since 2004 Tsunami event Sri Lanka and Myanmar has made developments in Early warning systems. As this research paper identifies the community preferred early warning systems are required to be identified and further improved to enhance the effectiveness of early warning.

Loud speakers are identified as a major impactful and effective early warning system in both the countries. Hence resource allocation to the loud speaker method as coordination plans for the system is required. A standard operational procedure for the loud speaker method should be made available in each community level and also constant training, drills and practical usage should be tested frequently.

EW towers in Sri Lanka needs to be further improved. An engineering solution is required to improve the range of towers. As well as more towers can be placed in expanding the range. A technological sharing of such systems within the region and outside the region will be helpful for both Sri Lanka and Myanmar in updating EW towers.

SMS, TV/Radio methods has direct warning dissemination from the upstream agencies to the grass root level individuals. Hence improving the trust and reliability of these methods will prepare the communities better in evacuation and disaster response. The network barrier and signal barrier are two major gaps in improving the systems. Further technical research work shall be conducted to find solutions.

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Investigation of the Institutions formed and empowered from disaster risk governance policies: Case studies from Sri Lanka, Myanmar and Maldives

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Abstract

Regardless of the country, communities are highly vulnerable and exposed to disasters induced by natural hazards. There is a number of disaster risk management mechanisms in place to mitigate and address disasters. A question unanswered regarding the disaster risk management mechanisms is why the damage and destruction due to disasters are not getting decreased and why are the same errors getting repeated. Hence, it is required to evaluate the effectiveness of these disaster risk management mechanisms to better tackle disasters. When understanding the disaster risk management mechanisms there are policies, which govern the mechanisms, and there are institutions, which operate, empowered and defined from these policies. Institutions that govern, plan, address and response to disasters are different and have different mechanisms of work. Networking, coordination, and dependencies of the institutions are a critical factor in disaster risk management. This research paper analyses the empowerment of institutions and identifies the placement of institutions in risk management mechanisms comparatively. The research study is based on case studies from Sri Lanka, Myanmar, and the Maldives. A number of community visits and institutional visits were conducted in three countries for the data collection of the research work. It was observed that in the above-mentioned countries, different approaches, techniques, and processes are used for disaster risk management. Hence, initially, this research study attempts to holistically understand the overall scenario of policies in place for disaster risk governance. As the next step, all the institutions were mapped and summarized for analyzing. The outputs from the research work can be used to understand the interdependencies of an institution in the disaster management mechanisms and to evaluate the involvement of each institution in disaster risk management.

Key Words: Risk Analysis, Disaster Management, Disaster Risk Reduction

1) Introduction

Disasters induced form natural hazards are a critical risk of the entire world. According to the world economic forum global risks perception survey for the year 2019 "Extreme Weather Events", "Failure of climate-change mitigation and adaptation" and "Natural disasters (Disasters induced from natural hazards) are the top three likelihood risks. Also in terms of impact top three risks consists with "Weapons of mass destruction", Failure of climate-change mitigation and adaptation" and "Extreme weather events". Whereas "Natural disaster (Disasters induced from natural hazards" is in the 5th position among top 10 risks in terms of impact. [2]

This indicates the exceptionally outstanding nature of the natural hazard induced disaster risk in terms of likelihood and impact. The question attached to this identification of the prime risks is "who is going to affect most?" Jochen Hinkel in 2018 published that the coastal communities are the most dynamic environments on earth. Hinkel further evaluates that the coastal societies do have a long history in facing and adapting to environmental changes. To further illustrate this fact, the total population of the world is above 7 billion. Whereas the highest population concentration is in low elevation coastal zones (defined as less that 10m elevation). [103]

With these two facts on natural hazard induced disaster risk magnitude and the areas which are going to affect most, this paper is written to evaluate the risk mitigation and addressing methods/mechanisms available as disaster risk management mechanisms. The disaster risk management mechanisms available and in use are unique to the area of exposure (Country, Region) yet has the drives form global frameworks such as the Sendai framework for Disaster Risk Reduction 2015 etc. Hence the approaches taken by each country in managing disaster risk in identifying disaster risk, assessing disaster risk, evaluating disaster risk and monitoring of disaster risk are diverse.

The disaster risk management mechanisms are composed from number of policies and frameworks which turns in to action from various institution and stakeholders. There similarities as well as differences in policies in place, stakeholders involved, collaboration mechanisms in place when comparing disaster management mechanisms. This paper identifies three disaster management mechanisms and compares the attributes of each mechanism. The disaster management mechanism of Sri Lanka, Myanmar and Maldives were compared for the above mentioned. The countries do carry identical disaster profiles and also carries same profiles in cultural, political and vulnerability status. A detailed reasoning of election of the disaster mechanisms are presented in a following section of this paper.

2) Methodology

A questionnaire survey was build up in assessing the disaster management mechanisms. [52] The survey was carried out in two segments, an institutional survey and a community survey. Institutional survey was conducted with key stakeholder institutions in each country with the objective of identifying the disaster management mechanism and understanding the role of each stakeholder. Whereas Community survey was conducted to understand the reality of practice in policies and framework in the grass root level and to identify the gaps in the mechanism.

In Sri Lanka Disaster Management Center, Department of Meteorology were visited for the institutional survey. The National Disaster Management Authority of Maldives, the

Meteorology Department of Maldives, Department of Meteorology and Hydrology of Myanmar, Department of Disaster Management of Myanmar were other institutions visited for the survey. Matara in Sri Lanka, Bu Gwe Gyi and Thazin Villages in Myanmar, and Maamigili in Maldives are the community areas visited for the community survey.

The paper is flowed with the identification of disaster management policies in each country. With that understanding on the policies available, which defines and empowers the institutions, the institutions involved are summarized for each country. The organizations which are in the disaster management system in the undisturbed situation were recognized as internal organizations and they were only considered for the research purposes.

3) Context of Sri Lanka, Myanmar and Maldives

The research work is focused on three case studies from Sri Lanka, Myanmar and Maldives. The three Asian countries were chosen as two island countries and one continental country.

The coast line length, total population, and coastal population of Sri Lanka, Myanmar and Maldives are as follows.

Attribute	Sri Lanka	Maldives	Myanmar
Coast Line Length	1340 Km	1129 Km	1930 Km
Total Population	21,336,833	532,668	59,094,870
Coastal Population	4,355,000	532,668	1,554,000

Sources: [91], [15],[90]

When looking at the cultural similarities, these countries do have collectivists culture, a high power distance, and same level of masculinity [36]. Also floods, abrasion, cyclones are similar hazard profiles with 2004 Tsunami as a break through disaster in policy changes., [15]

With these similar attributes the research work is focused to identify the policy implementation in each country.

4) Disaster Management Policies

After a thorough literature review on the policy documents available on each country and also by refereeing to the institutional survey data the policies of Sri Lanka, Myanmar and Maldives were summarized and identified as follows.

Disaster Management Policies of Sri Lanka

The institutions and legislations related to Disaster Management Mechanism of Sri Lanka have undergone several changes since 1977, where in 1977 it was the responsibility of Ministry of Social Services. A dedicated body to manage disasters was first recognized through the establishment of a National Disaster Management Centre (NDMC) under the Ministry of Health, Highways and Social Services during 1996. Then until the establishment of the Disaster Management Act in 2005 National Council for Disaster Management led the preparedness activities while the Department of Social services led the relief assistance. [32] [33]

Following are the formations of acts and policies in a timely order.

- Reconstruction and Rehabilitation Fund Act, No. 48 of 1993: Used to provide relief to persons affected, reconstruct of property and for rehabilitation.

- Disaster Management Act No. 13 of 2005: provides the institutional structure and governs the disaster management structure. And also defines the National Council for Disaster Management (NCDM) and Disaster Management Centre (DMC).

The Disaster Management Act of 2005, provided institutional structure to be adopted to facilitate the disaster risk management. The act assigns three broad functions to the NCDM. Policy formulation/planning, Monitoring and Ensuring disaster preparedness are the three functions. In addition the act authorise the relevant authorities to act upon the requirement such as empowering the president to declare a state of disaster.

After the act of 2005 there were number of policies, plans compiled with accordance to the international frameworks available and as per the timely needs. Following are the compiles of such nature.

- National Disaster Management Policy: prepared in 2010 according to the Hyogo framework for action.

- Ministry of Finance and Planning – Budget Circulars No. 152 (I) (II) and (III): Issued in 2013 and 2014: to mitigate the duplication of funding.

- National Disaster Management Plan: prepared for 2013-2015. Provides guidance to the formulation of the disaster management plans in all levels of administration.

- National Emergency Operations Plan: Provides guidelines for emergency preparedness (2015)

- Sri Lanka Comprehensive Disaster Management Programme: The action plan for 2014-2018

- National Adaptation Plan for Climate Change Impacts of Sri Lanka: is prepared for 2018-2025 in line with United Nations Framework on Climate Change.

- Sri Lanka Disaster Management Plan: prepared in accordance with Sendai Framework for the years 2018-2030.

Disaster Management Policies of Myanmar

Myanmar Disaster Management Mechanism (Herein after DMM) complied from;

- Disaster Management Law, 2013. (The pyidaun gsu Hluttaw Law No. 21,1013)

- Disaster Management Rules, 2015. (Notification no. 22/ 2015 from the Ministry of Welfare, Relief and Resettlement)

2013 dated disaster management law of Myanmar empowered number of institutions in disaster risk management. Ministry of Welfare, Relief and Resettlement is an institution empowered to carry out the office task. With the given powers the Ministry compiled the 2015 dated Disaster Management Rules for Myanmar. In following two sections the Disaster Management Law and Rules were comprehensively identified.

Disaster Management Law, 2013

Disaster Management Law compromised with 9 Chapters as described below.

Chapter 1 and 2 compromised with "Title and Definition" and "Objectives" respectively. The chapter one embarks the name of law and then defines the terms of State, Disaster, Disaster Management, Disaster Risk Reduction, Resource, National Committee, Local Body, International Organizations, Foreign regional organizations and Victims.

There are 5 objectives identified in the chapter two. Implementation and formation of programs and bodies. Coordination of different stakeholders, conserving the environment, and provisions management are specified as objectives.

Formation of National Disaster Management Committee and defining its Duties and Powers is done in the chapter 3. The union government is empowered to form and reform the National Disaster Management Committee (Herein after NDMC) from the clause No. 4 of the chapter 3. The clause No. 5 identifies 31 duties and powers of the NDMC. Laying down policies, forming supporting bodies, delegating duties to the relevant stakeholders, coordination with stakeholders, reporting, guiding and supervising are some of the key duties and powers mentioned. The clause No. 6 empowers The Ministry of Welfare, Relief and Resettlement to undertake the related office work.

Formation of Disaster Management Bodies and defining its Duties and Powers was done in the chapter 4. The Union government and the region or state government is empowered for formation of the disaster management bodies from clauses No.7 and No.8. The clause No. 9 defines the duties and powers of the National disaster management bodies. The actions and duties falls accordingly to implement the disaster management under the guidance of NDMC.

Chapter 5 defines the process of declaration of being a disaster affected area and authorize the president of the country to carry out the task. Clauses No. 11 and No. 12 empowers the President in declaring area as a disaster affected area.

The chapter 6 includes 6 clauses from No.13 to No. 18 which defines the functions on disaster management as follows.

- Clause No. 13: Defines the acts and powers of stakeholders in disaster management.
- Clause No. 14: Preparatory measures for disaster risk reduction before disaster.
- Clause No. 15: Preparatory measures to be organized before disaster in the area where is likely to strike the disaster.
- Clause No. 16: Preventive measures to be carried out in the area where is likely to strike disaster before the disaster
- Clause No. 17: Actions when the disaster strikes, emergency responses including search and rescue.
- Clause No. 18: Rehabilitation and reconstruction activities to be carried out after the disaster.

The Disaster Management Fund is established form the chapter 7. NCDM and Region or State bodies are empowered and defined the actions on establishing, reporting, budgeting, allocating, and auditing the funds under the clauses No. 19 to No.24.

A separate chapter (Chapter 7) is compiled with "Offenses and Penalties" regard to disaster management. Which includes clauses No. 25 to No. 31. They defines the types of offenses and the repercussions of each act.

Exemption of tax for provisions, use of uniforms, compensation entitlement, issuing of notifications are some of the entitlements listed under the final chapter 9, miscellaneous.

<u>Disaster Management Rules, 2015</u>

Disaster Management Rules include 12 chapters. Where Chapter 1 is on the Title and Definition of the rules.

Chapter 2, 3 and 4 identifies functions and duties the Ministry of social welfare, relief and resettlement, other relevant ministries, government departments, government agencies and also department.

Chapter 5 includes the Disaster management plans whereas chapter 6 describes the declaring a state of disaster affected area and its duration. Disaster preparedness and prevention for disaster risk reduction at the pre-disaster phase is rules under the chapter 7.

Emergency response activities including search and rescue during the disaster stage is ruled under the chapter 8. Final four chapters respectively ruled, Rehabilitation and reconstruction during the post disaster phase, Communication and collaboration with the assisting international actors Maintenance, expenditure and disposal of the national disaster management fund.

Disaster Management Policies of Maldives

The Disaster Management Act, 2015 of Maldives enables and empowers the disaster management mechanism of Maldives. Even though the act is legalized in the year 2015, there were number of guidelines prepared before that. The guidelines act as drivers of the disaster management mechanism. The delay of legalizing the act made the guidelines coming to action only after 2015.

The act is composed with the purposes as follows. (The following summary of the Disaster Management Act of Maldives is compiled from a translation obtained from the gazette issued in Thaana script.)

- To protect the people from natural hazards and man-made disasters.

- To incorporate guidelines on disaster risk mitigation and preparedness.

- To reduce disaster risk and to adapt a preparatory national strategy, to identify responsible parties to manage disaster risk, and to identify their responsibilities.

- To provide assistance at emergency situations and to provide assistance on the relief efforts, to incorporate such guidelines to coordinate such assistance.

- To state the roles and responsibilities of the City Councils, Atoll Councils, and Island Councils in reducing disaster risk and mitigation in emergency situations.

- To create awareness among the people in reducing disaster risk and mitigation in emergency situations, and to incorporate guidelines to protect the people from such dangers and enhance coping capacity.

- To incorporate disaster risk reduction guidelines and policies within the sustainable National development projects.

- To make the people responsible and accountable towards disaster risk reduction and mitigation

Other than to the act there are three guidelines in place to drive the disaster management mechanism of Maldives. The three guidelines are;

1. Community Based Disaster Management (CBDRM) Framework

2. National Internally Displaced People (IDP) Framework

3. Mainstreaming Disaster Risk Reduction into local development (Country report and action plan)

1. Community based disaster management framework

The framework is developed by the lead of Maldives National Disaster Management Center (herein after NDMC) on 2014. The (CBDRM) is of two parts. First part of it is the analysis of country assessment and a comparison assessment on institutional arrangement, human capacity, technical capacity, partnerships, and financial resources. Part two introduce the CBDRR strategy and implementation, monitoring and evaluation mechanisms.

2. National Internally Displaced People (IDP) Framework

This framework defines actions to be followed by local, national and international agencies to assist displaced people during a disaster situation.

3. Mainstreaming Disaster Risk Reduction into local development (Country report and action plan)

This guideline was prepared in 2014 with 6 modules. Concepts, use of tools, planning, developing, linking with local development planning and measuring are the aspects in detail described in the modules.

With this understanding on policies of disaster management from each country the research work is now directed in identifying the institutions involved in the disaster management mechanism. Most of these organizations were established and empowered from the policies implemented. Whereas some of the institutions due to the nature of work they carry out.

5) Institutions and Institutional Structures in Disaster Management Mechanisms

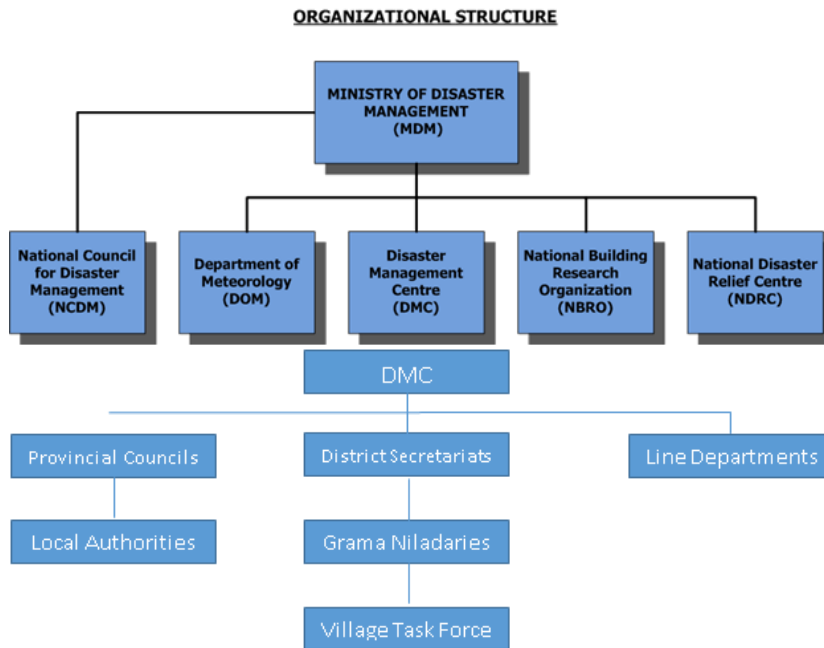**Organizational structure of Sri Lanka**

Figure 1: Upstream Organizational Structure of Sri Lanka

Organizational Structure of Myanmar

Figure 2: Upstream Organizational Structure of Myanmar

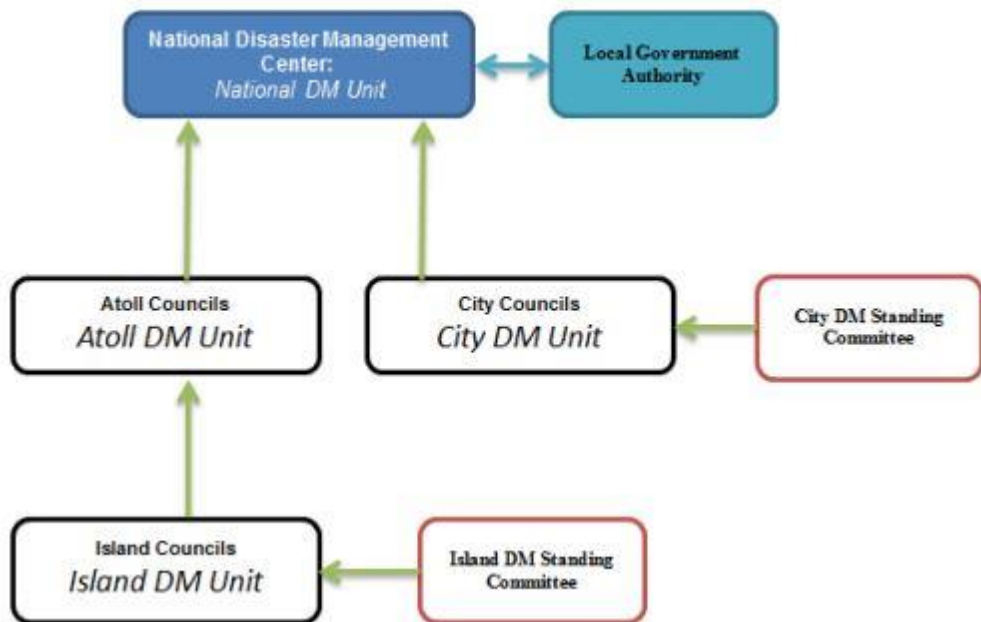## Organizational Structure of Maldives

Figure 3: Upstream Organizational Structure of Maldives

The institutions and coordination patterns illustrated in the above figures demonstrate the upstream mechanisms in disaster management mechanism. It can be observed the umbrella behavior of organizational structure where the power and work are delegated along the organizational structure. One major contrasting difference in these organizational structures is that in Myanmar structure the upstream structure is directly delegating work in a matrix system whereas in Sri Lanka and Maldives it is created a platform for the coordination of relevant institutions.

There are number of other institutions involved in directly to the disaster management mechanism. The internal stakeholder involvement in overall disaster management mechanism is analyzed in the following section.

Summary of Institutional Involvement

The following table was prepared to compare the institutional arrangement from disaster management policies. The institutional involvement was categorized under three divisions namely; planning for disaster risk, Disaster risk monitoring and disaster treatment.

Planning for disaster risk involves the establishment of risk context (disaster management policy planning), risk identification (disaster and hazard mapping), risk pretreatment (disaster risk reduction) activities. The institutions listed under that category are empowered and established institutions in each country to carry out and conduct such work.

Disaster risk monitoring activities involve the early warning related institutions of each country. Similarly the disaster treatment related institutions are whom responsible and empowered to carry out emergency response and recovery of a disaster.

Table 1: Overall internal organizational identification of Sri Lanka, Myanmar and Maldives

Disaster / Risk Stage	Sri Lanka	Myanmar	Maldives
Planning for Disaster Risk	National Council for Disaster Management	National natural Disaster Management Central Committee	National Steering Committee
	Ministry of Disaster Management	State Working Committees	National Disaster Management Authority
	Disaster Management Center	Ministry of Home Affairs	DRR Unit
	Ministry of Defense	Ministry of Social Welfare, Relief and Resettlement Department	Cooperate affairs unit
	Ministry of Health	Ministry of Health	
	Other line ministries	Ministry of Foreign Affairs	
		Department of Disaster Management	

	Sri Lanka	Myanmar	Maldives
		Asian Disaster Reduction Center	
		ASEAN Committee on Disaster Management	
Disaster Risk Monitoring	Department of Meteorology	Department of Meteorology and Hydrology	Meteorology Department
	Department of Irrigation		
	National Building Research Organization		
	National Aquatic Resources Research and Development Agency		
	Marine Environment Protection Authority		
	Geological Survey and Mines Bureau		
Disaster Treatment	National Disaster Relief Services Center	Relief and Resettlement Department	National Emergency Operations Center
	Provincial Councils	Emergency Operation Centre	National Emergency Response forces
	District Secretariat Offices	District Working Committees	Maldives National Defense Forces
	Divisional Secretariat Offices	Township Working Committees	Atoll DM units
		Village Working Committees	City DM units
		Armed forces of Myanmar	Island DM units

Sources: [104], [105], [106], [107]

6) Conclusion

In Sri Lanka, Myanmar and Maldives the upstream of the disaster management mechanism has the highest level of involvement from power hierarchy. It was essential and evident that well attained in three countries. The head of the state chairs the top most committee/council established for disaster management. Also from the policy identification it was evident that these institutions and personals were given adequate empowerment to effectively manage a disaster event.

The mechanism under these top bodies are different in contrast. Whereas in Sri Lanka the top body act as a platform to generate the collaboration of all the other parties. In Myanmar the 12 working committee mechanism is downscaled in four steps. Whereas in Maldives it has the similar structure as Sri Lanka.

In Maldives and Myanmar it was only being able to identify Meteorology department and Department of Meteorology and Hydrology respectively as the sole bodies responsible for the hazard monitoring and early warning generation. The early warning dissemination processes are different in each country. In Sri Lanka certain other bodies were identified as responsible for hazard monitoring from the system.

In disaster treatment (Emergency response stage and recovery stage) the Sri Lankan and Maldives has an identical system with direct government involvement. Whereas in Myanmar the system is community based. The structure at Myanmar empowers the community to own the disaster management and building back phases.

The prepared summary of elements only include the internal institutions. There are external institutions as well. Analyzing and comparing their involvement is an extension of this research work. Also other than to these institutional work there exists a people hierarchy which affects the overall effectiveness of disaster management mechanisms.

The effectiveness of each system in managing an identical disaster (2004 Tsunami) is an extension of this research work. Such analysis will enable an evaluation of each stakeholder and will critically identify the most effective mechanism.

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      _2=&bt_1=&bt_10=&st_10=&ge_9=&le_9=&bt_3=&st_3=&type_19=EXACT&query_1
      9=None+Selected&op_17=eq&v_17=&bt_20=&st_20=&bt_13=&st_13=&bt_16=&st_1
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Annex 8: Conference Paper, International Conference on Building Resilience – Indonesia, January 2020

Framework To Evaluate Institutional Relations In Disaster Management Mechanisms

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ABSTRACT

Disaster Management mechanisms are made up with various elements. Governing bodies, Monitoring institutions, Warning disseminations institutions, External organizations, volunteers, affected community are some of the common elements in a disaster management mechanism. The mechanism uses different level of contribution from each of the element in succeeding a disaster. These elements do have different roles and different levels of interest in involving. Hence, the disaster management mechanism gets in to a complicated system. It is a need to get the maximum use of each element given that each of these elements are resources in disaster risk reduction mechanism. The understanding of the relations among each of the element is a necessity in disaster risk reduction activities planning and executing. Humans and Institutions are major components in such mechanisms. This paper evaluates the behaviour of these two components using case studies from Sri Lanka, Myanmar and Maldives. Institutions from Disaster Management mechanism of each country is compared in the behavioural patterns. Level of interactions with other institutions, level of interactions with humans, level of power delegation and boundary of work are criteria used in comparing. The founded results were then used to validate a human – institutional behaviour framework.

7   INTRODUCTION

The 2004 Tsunami was an eye opener in to disaster management topic in most of the affected countries. 2004 Tsunami resulted over 230,000 deaths across more than 15 countries across Asia to Africa. [6] The earthquake had a recorded magnitude of 9.1, origin at coast of Northern Sumatra (3.295°N 95.982°E) with a depth of 30km on December 26th, [89].

Among the countries affected this research paper is based on Sri Lanka, Myanmar and Maldives. Sri Lanka do have a total coast line length of 1340 Km and a coastal population of 4,355,000. In Myanmar it's 1930 Km and 1,554,000 whereas in Maldives it is 1129 Km and 532,668 people [91]. These countries do have a collectivist culture, a high power distance, and same level of masculinity as cultural similarities.[14] With these similar attributes the research work is focused around Sri Lanka, Myanmar and Maldives.

Tsunami disaster in 2004 was a breakthrough event in disaster management where there were number of policies and frameworks planned, empowered and implemented by responsible governing bodies to successfully mitigate, reduce risk, and to manage the disaster risk. [100] These policies empower, create and set the scope for number of institutions to carry out the disaster management tasks. An important aspect in institutional implementation is the coordination, networking among these institutions. The level of these correlations defines the total effectiveness in overall effectiveness of disaster management mechanism [52].

All the institutions involved in disaster management mechanism have a vital role. Also the methods and involvement of each organization is categorically unique and has its own correlation mechanisms and levels. It is important to understand the correlation behaviour of these institutions. Given these facts the identification of the categorical systematic relations of the institutions is a necessity to understand the overall effectiveness of disaster management mechanism.

This paper identifies the overall institutional involvement in disaster management mechanism in Sri Lanka, Maldives and Myanmar. Then propose a framework to identify the correlative mechanism of each of the institution.

8   Methodology

The data presented in this paper are collected from surveys and interviews conducted at Sri Lanka, Myanmar and Maldives. A questionnaire survey was build up in assessing the disaster management mechanisms [53]. The survey was carried out in two segments, an institutional survey and a community survey. Institutional survey was conducted with key stakeholder institutions in each country with the objective of identifying the disaster management mechanism and understanding the role of each stakeholder. Whereas Community survey was conducted to understand the reality of practice in policies and framework in the grass root level and to identify the gaps in the mechanism.

The identified institutions were then sorted in risk management framework in a comparative manner for Sri Lanka, Myanmar and Maldives as presented in the next section of this paper.

With that identification of the institutions the framework to evaluate the correlative and systematic relationships of institutions was then developed.

9 Institutional Arrangements in Disaster Management Mechanisms

Institutional survey conducted and the country specific disaster management policies were referred to extract and identify the institutions available in each country [32], [105], [106].

The identified institutions are categorized under planning for disaster risk, disaster risk monitoring and disaster treatment as illustrated in the tables. The category titles are compromised from risk management process literature available. Planning for disaster risk involves the establishment of risk context (disaster management policy planning), risk identification (disaster and hazard mapping), risk pre-treatment (disaster risk reduction) activities. The institutions listed under that category are empowered and established institutions in each country to carry out and conduct such work. Disaster risk monitoring activities involve the early warning related institutions of each country. Similarly the disaster treatment related institutions are whom responsible and empowered to carry out emergency response and recovery of a disaster.

The following are the compiled institutions empowered and established from the policies in Sri Lanka, Myanmar and Maldives. The institutions are illustrated in a categorized manner according to the risk processes as mentioned above.

1.1 Institutions empowered and provisioned for Disaster Management in Sri Lanka

Table 1: Institutions provisioned for Disaster risk planning

Planning for Disaster Risk	Operational Level
National Council for Disaster Management	National
Ministry of Disaster Management	National
Disaster Management Center	National /Local
Ministry of Defense	National
Ministry of Health	National
Other line ministries	National

Table 2: Institutions provisioned for Disaster risk monitoring

Disaster Risk Monitoring	Operational Level
Department of Meteorology	National / International
Department of Irrigation	National
National Building Research Organization	National
National Aquatic Resources Research and Development Agency	National
Marine Environment Protection Authority	National
Geological Survey and Mines Bureau	National

Table 3: Institutions provisioned for disaster treatment

Disaster Treatment	Operational Level
National Disaster Relief Services Center	National / Local
Provincial Councils	Local
District Secretariat Offices	Local
Divisional Secretariat Offices	Local

1.2 Institutions empowered and provisioned for Disaster Management in Myanmar

Table 4: Institutions provisioned for Disaster risk planning

Planning for Disaster Risk	Operational Level
National natural Disaster Management Central Committee	National
State Working Committees	National
Ministry of Home Affairs	National
Ministry of Social Welfare, Relief and Resettlement Department	National
Ministry of Health	National
Department of Disaster Management	National
Asian Disaster Reduction Center	International
ASEAN Committee on Disaster Management	International

Table 5: Institutions provisioned for Disaster risk monitoring

Disaster Risk Monitoring	Operational Level
Department of Meteorology and Hydrology	National / International

Table 6: Institutions provisioned for Disaster treatment

Disaster Treatment	Operational Level
Relief and Resettlement Department	National
Emergency Operation Centre	National
District Working Committees	Local
Township Working Committees	Local
Village Working Committees	Local
Armed forces of Myanmar	National / Local

1.3 Institutions empowered and provisioned for Disaster Management in Maldives

Table 7: Institutions provisioned for Disaster risk planning

Planning for Disaster Risk	Operational Level
National Steering Committee	National
National Disaster Management Authority	National
DRR Unit	National
Corporate affairs unit	National

Table 8: Institutions provisioned for Disaster risk monitoring

Disaster Risk Monitoring	Operational Level
Meteorology Department	National / International

Table 9: Institutions provisioned for Disaster treatment

Disaster Treatment	Operational Level
National Emergency Operations Center	National / Local
National Emergency Response forces	National / Local
Maldives National Defense Forces	National / Local
Atoll DM units	Local
City DM units	Local
Island DM units	Local

Table 1, Table 4 and Table 7 illustrates institutions empowered by policies in Sri Lanka, Myanmar and Maldives respectively to plan for disaster risk. Table 2, Table 5 and Table 8 illustrates the risk monitoring institutions identified from policies available for risk monitoring in above countries respectively. Whereas Table 3, Table 6, and Table 9 illustrates institutions empowered to conduct disaster treatment activities in each country.

With this understanding on institutions on disaster management mechanism of each country the framework to evaluate the correlations of institutions was developed.

10 Outline of the evaluation framework

There are mainly two parts of relations analyzed and focused on to understand the behavior of institutions in a disaster management mechanism. Given that disaster management mechanisms are compromised with institutions and people, the two parts of relationships are inter institutional (I-I) relations and human – institutional (H-I) relations as illustrated in the figure 1.

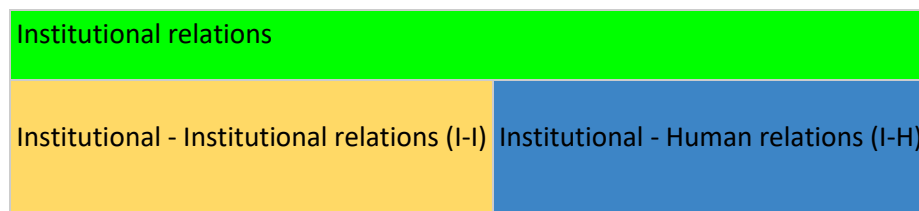| Institutional relations	
Institutional - Institutional relations (I-I)	Institutional - Human relations (I-H)

Figure 1: Institutional relations

Under each section there are criteria's formed to access the level of the correlation. Once an institution is evaluated under all the criteria's institution can be mapped to compare and cluster. The evaluation framework does not score and evaluate the institutions in most important to least important but cluster the institutions according to the levels of interactions they have.

1.4　　　　Institutional – Institutional relations

There are five criteria's proposed in identifying the "I - I" correlations as illustrated in the table 10.

Table 160 I –I Criteria

Criteria No.	Criteria	Response
1.1	Interaction requirement with organizations higher in the power rank	Positive/Negativ
1.2	Interaction requirement with organizations lower in the power rank	Positive/Negativ
1.3	Interaction requirement with internal organizations in DMM	Positive/Negativ
1.4	Interaction requirement with external organizations in DMM	Positive/Negativ
1.5	Number of total interactive organizations	Cumulative Nun

Power rank is the organizational hierarchy of the country and disaster management mechanisms. There are organizational charts available in Sri Lanka, Myanmar and Maldives which can be used in this criteria [52]. Internal and external institutions are defined as according to the system of disaster management mechanism. Whereas institutions which aren't part of the system during the undisturbed stage of the system are external institutions and institutions which are in the system during the undisturbed stage are internal institutions.

In policy definitions there are provisions made to create the coordination among institutions. Institutions do need to coordinate with other organizations who are having higher authority level, to take the guidelines and direct orders, and pass them as actions or messages to the fellow institutions. These behaviors are evaluated in the criteria 1.1 and 1.2.

In system (community and disaster management) the provisions are provided on mainly on interactions among the internal institutions. Hence the approaches taken by institutions in interacting with institutions internal and external are different. This behavior is evaluated in the criteria 1.3 and 1.4.

Also in the network the total points in the loop are defined the communication criticality of an institution. This is measured in the criteria 1.5.

Criteria 1.1, 1.2, 1.3, and 1.4 has a direct one zero answer. The positive answer gains 1 point and negative answer gains 0 point. There are in middle (fractional) points for those four criteria's.

Whereas in the criteria 1.5 gains fractional point. Maximum gaining is 1 and minimum is 0. The calculation of this point is based on comparison of institutions. The institution with most

number of interactive organizations get the highest point and the institution with the least number of interactive organizations gets minimum point. Other organizations gets in between points as proportional to the two benchmarks (The highest and the lowest).

1.5 Institutional – Human Relations

There are four criteria's proposed in identifying the "I - H" correlations as illustrated in Table 11.

Table 171 I – H Criteria

Criteria No.	Criteria	Response
2.1	Top most interaction point in people hierarchy	1-10
2.2	Bottom most interaction point in people hierarchy	1-10
2.3	Percentage number of people directly interacts with	Percentage
2.4	Percentage number of people indirectly interacts with	Percentage

People hierarchy is the pillar of peoples as mentioned in the literature: Lessons Learned from Interventions of External Organizations In Disaster Management: Case Study of Floods in Kalutara, Sri Lanka [53]. The pillar is of a cone as illustrated in the figure 2. The power of people is varying along the vertical axis.
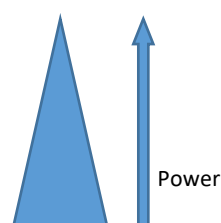

Figure 2: People hierarchy

Direct involvement defined here is the people who can directly communicate with the institution. This includes the people who are working to the institution as well. The people who involves in direct discussions with the institution, people who have veto power over the institution, people who receives communications (messages, orders, guiding etc.) directly from the institution and people who directly send communications (messages, updates, etc.) to the institutions compromised the people who directly interacts with institution.

Indirect involvement is people who has impacts on actions of the institution yet do not communicate directly with the institution. These people gets the benefit out of the actions yet has minimum capability in defining the actions of the institution.

Institutions are governed by people who are in different layers of people hierarchy for different institutions. This behavior of institutions and people are measured in the criteria 2.1 and 2.2. The beneficial party of the institutional activities are the people of the community. Yet the way of beneficial is completely depend on the institutional activity nature decisions. That is measured in the criteria 2.3 and 2.4.

Criteria 2.1 and 2.2 has a combined point range from 0 to 2, including fractions. The difference of criteria 2.1 and 2.2 in compared to the total people hierarchy defines the amount of points gained by an institution. For an example if an institution has the top most interaction point as the top most position of the people hierarchy and the bottom most point as the bottom point of the people hierarchy then the institution has a 100% range hence gains total points, two.

In criteria 2.3 and 2.4 the percentage is calculated as a portion of the total population of the country. Each criteria has a point range from 1 to 0 including fractions. 100% equals to 1 and 0% equals to 0.

1.6 Institutional Map

With the data generated as per the above mentioned framework for each country a graph was produced. The "I – I" data used as the Y axis and "H – I" as the X axis.
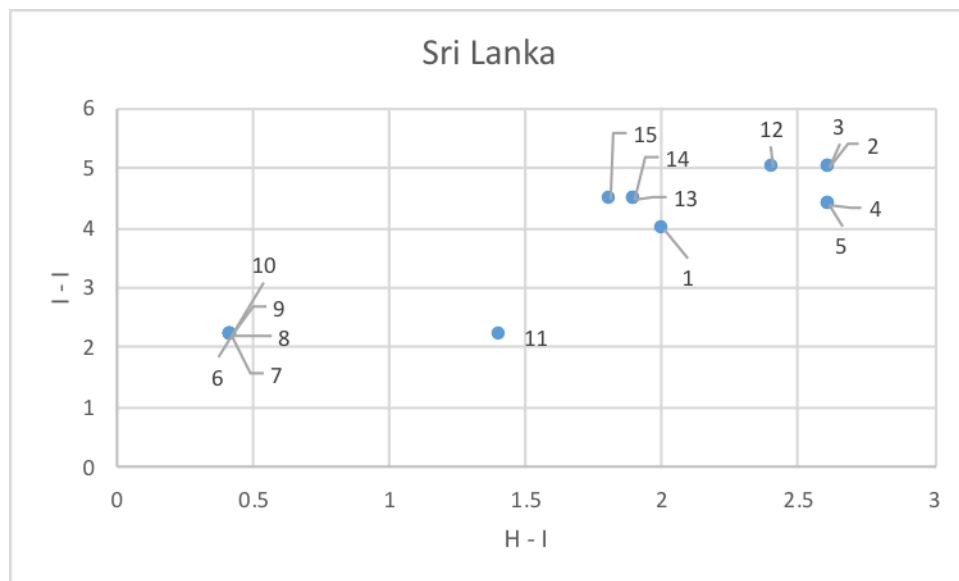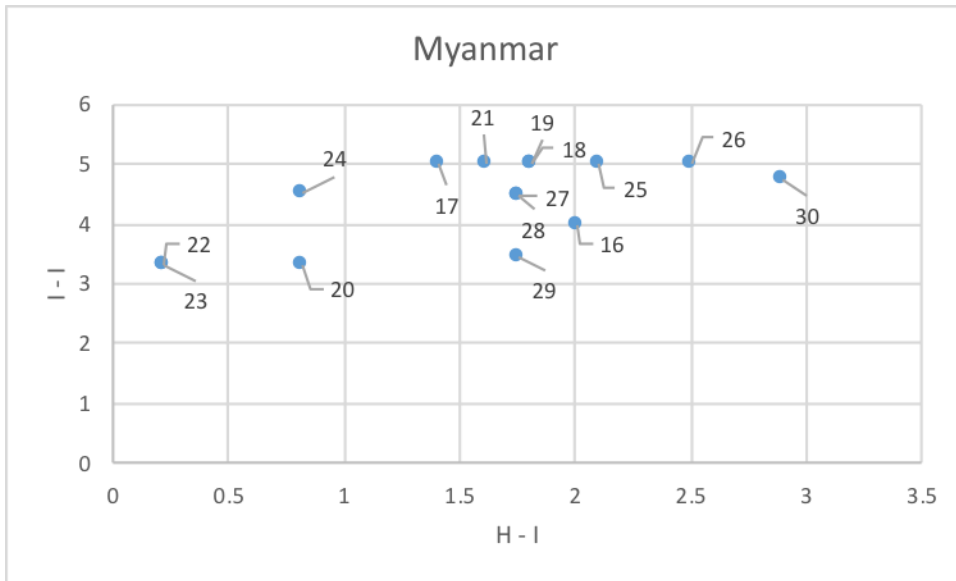

Figure 3: Institutional Map of Sri Lanka
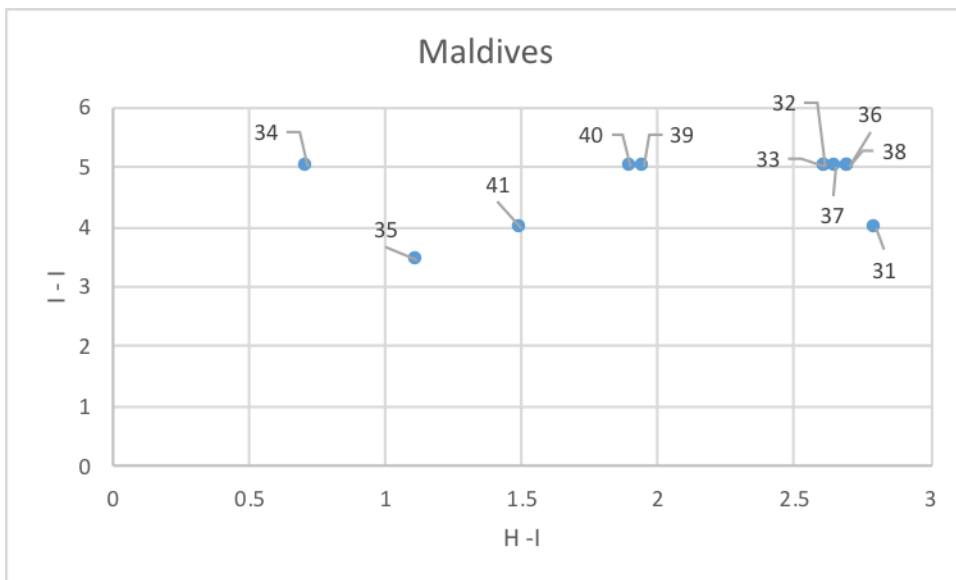
Figure 4: Institutional Map of Myanmar

Figure 5: Institutional Map of Maldives

For Figure 3, 4 and 5 following is the legend, Figure 6.

No	Institution	No	Institution	No	Institution
1	National Council for Disaster Management	16	National natural Disaster Management Central Committee	31	National Steering Committee
2	Ministry of Disaster Management	17	State Working Committees	32	National Disaster Management Authority
3	Disaster Management Center	18	Ministry of Home Affairs	33	DRR Unit
4	Ministry of Defence	19	Ministry of Social Welfare, Relief and Resettlement Department	34	Corporate affairs unit
5	Ministry of Health	20	Ministry of Health	35	Meteorology Department
6	Department of Meteorology	21	Department of Disaster Management	36	National Emergency Operations Center
7	Department of Irrigation	22	Asian Disaster Reduction Center	37	National Emergency Response forces
8	National Building Research Organization	23	ASEAN Committee on Disaster Management	38	Maldives National Defence Forces
9	National Aquatic Resources Research and Development Agency	24	Department of Meteorology and Hydrology	39	Atoll DM units
10	Marine Environment Protection Authority	25	Relief and Resettlement Department	40	City DM units
11	Geological Survey and Mines Bureau	26	Emergency Operation Centre	41	Island DM units
12	National Disaster Relief Services Center	27	District Working Committees		
13	Provincial Councils	28	Township Working Committees		
14	District Secretariat Offices	29	Village Working Committees		
15	Divisional Secretariat Offices	30	Armed forces of Myanmar		

Figure 6: Legend (Numbering of institutions)

Figure 3 indicates the map of institutions of Sri Lanka whereas Figure 4 and Figure 5 respectively presents the map of institutions in Myanmar and Maldives.

Above graphs are developed with the limited data available. Hence a specific analysis on the graphical illustrations would not enhance an accurate picture of the data. A detailed presentation of the use of the developed method and framework is discussed in the following section.
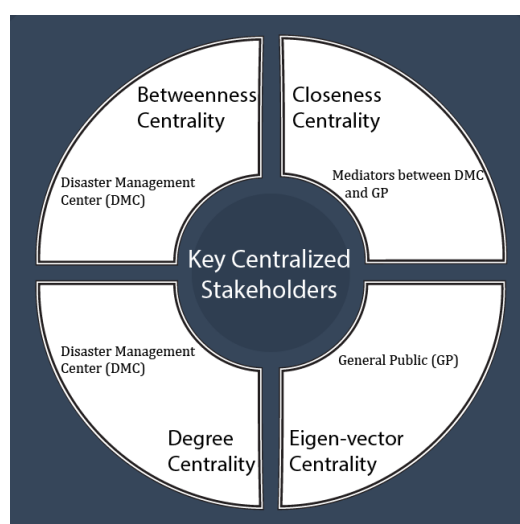

Figure 7: Stakeholder behaviour of Disaster Management

Figure 7 (Source: [43]) is from a research conducted using the Social Network Analysis. This identifies the stakeholder behavior of Disaster Management. Overall policies and institutional structures indicates the centralized umbrella behavior of the disaster management framework of Sri Lanka. When compared with the results of this research work, it is identical that the disaster management mechanisms of Myanmar and Maldives has the centralized umbrella behavior.

11 discussion

The method can be used to tier and cluster the institutions in disaster management mechanisms to evaluate the institutions with respect to the correlations. The clustering can easily point out the gaps and areas to improve while the related decisions can be generalized accordingly.

The comparing mechanism enhances the illustration of institutional priorities and critical natures. Hence it is possible to understand the solutions for each institutions and look for options to repeat the same solution.

There are number of patterns identifiable from the graphs produced. It is evident that the top most bodies and has similar positioning (Need to verify with further data) whereas the risk monitoring related institution/s are having different positioning. Likewise there can be patterns identified and further analysis on these patterns is another extension of study.

When allocating resources for institutions with the understanding of which institution is critical in correlations specific experts and extra resources allocation can be done in much logical pattern.

The framework can be further expanded with further criteria. The given criteria too can be further strengthen in order to capture the best illustration of institutions. The framework is to be improved with more data and validation is an extension of the research study

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