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BUILDING A TSUNAMI DISASTER RESILIENT COASTAL COMMUNITY IN SRI LANKA

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ABSTRACT

Natural disasters are inevitable, but strategic planning could alleviate or ameliorate their adverse impacts. The frequency of natural disasters in Sri Lanka has risen over the past few decades, thus the number of disaster-affected communities, casualties, and victims have clambered simultaneously. It is has been observed that in Sri Lanka, strategic dealing has not strengthen enough the needed modification of community-level planning for evacuation, for emergency preparedness systems, or for the needed advance considerations that must be evaluated and taken by the appropriate Civil Defense authorities. Thus, the main focus of the present research is to review the vulnerable coastal communities that were affected by the 26 December 2004 tsunami, and to determine which may still be at risk from future disasters. The research objective is based on three main questions: a) How resilient are today Sri Lankan coastal communities? b) Why is resilience critical to these coastal communities? c) What is needed to build coastal hazard resilient communities? The research proposes that solutions could be possible with a specific identification study on how to bridge the gap between the current national-level proposals and the practical applications at the community-level. This study could be further helpful in enhancing viable relationships among local governments and coastal communities in evacuation planning for future tsunami disasters.

Keywords; *Tsunami Disaster Resilient Coastal Community, Resilience Gap, Community-level Risk Assessment, Community Participation in Mitigation, Evacuation*

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1. INTRODUCTION

Natural disaster resilience is the capacity of a community to adapt and influence the change caused by a particular natural disaster. Sri Lanka was a not considered as a natural disaster-prone country until a few decades ago. But the situation by now has changed drastically. Furthermore, coastal communities around the world are experiencing presently an unprecedented rate of change due to population growth in the coastal areas, humanly induced vulnerability, and global climate change. The effects of this change are placing communities at increasing risks from coastal hazards such as tsunamis, severe storms, and shoreline erosion. [2]

The frequency of natural disasters in Sri Lanka, which are considered as coastline hazards include tsunamis, storms, coastal beach erosion, and inland hazards such as landslides, floods, and a variety of other collateral catastrophes, which have been increasing over the past few decades. As a result, disaster-affected vulnerable communities and resulting casualties are rising annually. It is obvious that tsunamis constitute the highest risk disaster for Sri Lanka's coastal communities - as determined by the impact of the 26 December 2004 event. The records of this particular event revealed clearly which coastal communities have a high possibility to become vulnerable again. High population density and massive sudden threat levels of tsunamis, could be considered as the main reasons for increasing the coastline hazard risk.

The present study considers risk evaluation, early warning efficiency, evacuation and emergency responses as important elements in improving the existing low resilience level of coastal communities. Furthermore, the study identifies the low resilience level of coastal communities through hearings and onsite observations conducted based on the above elements (Early Warning and Evacuation and Emergency Response) on the research fields. The current resilience level of the coastal communities has been recognized as being at the 40% level, which indicates that there is a 60% gap in order to achieve the ideal condition. This has been determined by a quantitative data analysis research which was done at Panadura coastal DS (District Secretarial) division [6] Fig. 2. The research was conducted under the framework proposed by UNSAID 2007 and it combines eight significant resilient elements: Governance, Society and Economy, Coastal Resources Management, Land-use, Structural Design, Risk Knowledge, Warning and Evacuation, as well as Emergency Response and Disaster Recovery. Fig. 1.

The present research identifies that most of the risk assessments and evacuation programs such as the PDNA (Post Disaster Need Assessments) action programs and the NDMP (National Disaster Management Plan) are being focused on the more frequent hazards such as floods and landslides. Hence, in our research we propose that due to the non-predictability massive level, there should be no less priority for sudden coastline hazards like tsunamis.

The first step in establishing resilience should be the identification and determination of actions that need to be taken to reduce the risk of the hazard. Therefore, building on lessons learned and experienced gained, is important. Hence the Sri Lankan coastline is most in need of building resilience. How to enhance resilience through a top-down system has become the most challenging

task at present for all types of hazards in the country. The present study identifies the well established and organized national level emergency response and evacuation guidance programs which have been conducted nationwide, mainly by the DMC (Disaster Management Centre) - the top-level disaster mitigation authority of the country - but with rather low level of participation at the community-level. Consequently, there should be a proper assessment of risk by each local community, so that the understanding of the risk can be impacted positively in address properly each community's resilience.

Fig.1. Elements of coastal community resilience. (Source: USAID/ASIA Report 2007)

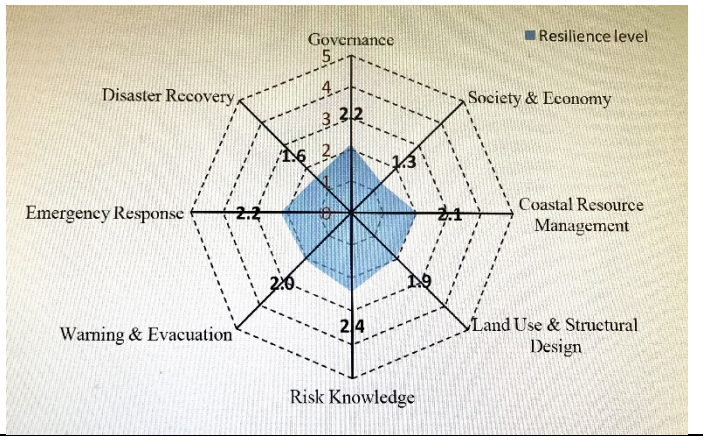


Fig. 2. Resilience Level Coastline Sri Lanka (Source: Coastal Community Resilience level of Tsunami prone area, procedural Engineering 212(2018) p.686)

1.1. Past Disaster Experiences on the Sri Lanka Coastlines

The 2004 Great Sumatra tsunami claimed the lives of 35,000 people in Sri Lanka and displaced one in twenty. The disaster highlighted the critical importance of developing an effective National Early Warning System (NEWS: SL). [5]. The tsunami generated by the 9.2 magnitude 2004 Indonesian earthquake, affected two-thirds of the entire coastline Sri Lanka. The disaster destroyed 80,000 houses and partially damaged another 40,000. The total economic loss in housing, infrastructure, tourism, and fisheries sectors was estimated at more than US $900 million. [7]. Since it was the first major disaster that impacted the entire coastline of the country, the damage was high, primarily due to the lack of safety building codes, of adequate land use planning and of evacuation procedures for coastline communities. In the post-disaster period, major reconstruction projects were implemented with financial support of the Sri Lanka government and of many national and international donor organizations to help obtain full recovery.

Two types of permanent housing programs were dedicated in repairing and rebuilding the damaged houses. They were known as reconstruction programs established on the coastline, and resettlement programs, established inland on lands away from the original coastal sites. Unfortunately, the most essential part of post-tsunami reconstruction and safety concerns on the coastline, were neglected during the reconstruction process. In the beginning, a 200m buffer-zone regulation (Set-back Zone) was proposed by the coastal conservation department, but later it was revised several times and was

reduced to a minimum of 35m which could be difficult to count as a safety precaution. Hence there is a great necessity for revisions and of more efficient emergency evacuation planning for coastal communities.

2. RESEARCH QUESTIONS

1. How resilient are Sri Lankan coastal communities today to natural disasters?
2. Why natural disaster resilience is critical to Sri Lanka's coastal communities?
3. What is needed to build a resilient community for tsunami and other coastal hazards?

3. RESEARCH HYPOTHESIS

The main objective of the study is to emphasize to top-level decision makers the importance of community-level risk assessment at each coastal community. Additional objective is to provide support to the Sri Lankan coastal communities to know the possible tsunami risk at the community-level (in an easily understandable manner), so that it will be helpful to increase the disaster awareness and active community participation in current disaster mitigation and evacuation activities. Finally, another objective of the study is to promote active community participation, such as community-level hazard map development, and other related information needed for disaster mitigation for preparedness activities and evacuation from risk areas, and for enhancing future disaster resilience and address DRR (Disaster Risk Reduction) aspects strategically.

4. METHODOLOGY

Onsite observations were completed in Mirissa south 1 and 2, GN divisions (*Grama Niladari* division/Village) in Matara DS division (District Secretarial division) in the southern coastline of Sri Lanka, from 30/01/2019-01/02/2019. Data was gathered through multiple collection methods, literature surveys, community hearings, simple questionnaire surveys, informal interviews of government officers of authorities such as the Disaster Management Centre, at the Colombo head office, project officers of the disaster management division in Matara District Secretaries office, the village officers in Mirissa GN divisions, as well as from municipal drawings, field visits, and informal interviews with people of different communities.

5. EXPLANATION OF REREARCH QUESTIONS

5.1. How resilient are Sri Lankan coastal communities today to natural disasters?

Presently, Sri Lanka is receiving considerable attention at the international level as a natural disaster-prone country and substantial assistances to upgrade the resilience level of its citizens for natural disasters.

Most of the recent recovery plans have focused on those disasters which occur frequently, such as floods and landslides. The Post Disaster Recovery Plan (PDRP) for floods and landslides of May 2017 was developed as a collaborative effort of the Government of Sri Lanka with United Nations

agencies, the World Bank, the European Union, and other organizations. In response to catastrophic floods and landslides that affected the entire country in May 2016 and May 2017, a Post Disaster Assessment (PDNA) study was conducted which assessed both the effects and the recovery needs, across affected sectors and districts. PDNA directed the development of the National Disaster Management Plan, including the Comprehensive Action Program for five years for the 2018-2023 period, and the Sri Lanka Comprehensive Disaster Management Program (SLCDMP). This plan further explains it would take into account recommendations for medium- and long-term recovery needs, outlining in PDNA and global targets outlined in the Sendai Framework for Disaster Risk Reduction and sustainable development goals. The Department of National Planning initiated the Post Disaster Recovery Plan (PDRP) and the Recovery Framework in September 2017 with the assistance of the World Bank and UNDP.

Additionally, recognized by the National Disaster Management Plan was the need for advanced disaster mitigation and emergency evacuation system for the coastline communities. Thus the national plan that was subsequently established, included disaster awareness and preparedness, training, mitigation research and development, emergency operations, early warning system procedures and evacuation of the public from risk areas. Based on interviews with top-level officials of the safety planning hierarchy, it was determined that the national plan is now well organized and properly executes the assigned tasks throughout the country. However, based on further observations, it was also recognized that when a natural disaster occurs, the resilience for recovery at the community-level remains a critical issue. This could be identified as lack of knowledge in preparing to deal with actual disaster situations in those communities. At present, how to fulfill the gap between the local community level and the national authority level, has become a greater challenge in achieving natural disaster resilient communities.

The high coastal population density also increases the risk level. Since over 50% of the total population live in maritime districts and of this 42.7 % live in the coastal region, the coastal region has to play a greater role in meeting the major challenges of the nation. The tsunami impact on coastal regions also reflected in the fishing and the tourism sub-sectors. Future development planning in the coastal region is needed because it has significant implications for the national economy according to the National GDP through the Coastal GDP. Coastal GDP in 2004 was reduced clearly by the Year 2005. [1]

Figure 2 reveals the coastal community resilience level by the year 2018 and it is clear that the coastal community of Sri Lanka further needs to enhance their resilience to a tsunami in all dimensions of the resilience framework of USAID 2007. [6] Therefore, the elements of Early Warning and Evacuation and Emergency Response play a great role.

5.2. Why the Natural Disaster Resilience is Critical to Sri Lankan Coastal Communities?

A major issue that still remains is on how to bridge the gap between the current national level safety and evacuation proposals and practical applications at the community level. Hence, emphasizing the importance of obtaining advance knowledge on the possible risk from future earthquakes and

tsunamis for the top-level decision-makers is still an issue not properly achieved. Achieving such understanding would be helpful to continually conduct risk assessments and evacuations programs in a more positive and effective manner at the local coastline community level. Presently there is insufficient understanding of the possible risk of coastal communities to the potential impact of future earthquake and tsunami disasters. Increase in the awareness of future tsunami risks and of the needed evacuation, has become a challenge. The actual risks for each coastal community need to be assessed and evaluated separately.

The majority of the post-disaster reconstruction projects on the southern coastline had been established without proper safety measures or adequate evacuation procedures. This means that the beneficiaries don't feel safe in the buildings which they received by donor parties, which still have to assessed for safety precautions from the basic level.

The Sri Lankan navy forces are responsible presently for conducting safety activities and maintaining the safety level of communities along the coastline. For this reason they conduct an annual evacuation drills for the coastline communities with the support of the GN division and DS division officers. Additional reason for the drills is to be combine strategic and community friendly manner/practices with community leaders in order to improve communications between local community members and authorized decision making officials.

5.3. What is Needed to Build an Effective Coastal Hazard (Tsunami) Resilient Community?

In order to make the existing National Early Warning System and community-level strategies more effective, steps must be taken to issue in a timely manner the evacuation warning to the threatened coastal communities. This needs to be done through simple community-friendly methods and directives about the potential threat and thus enhance the safety of each vulnerable community. To accomplish this objective the following steps are suggested:

- Proper and shared community-level risk assessment among community members, which will include recognition of hazards areas and safety zones, which are supported by simple and accurate hazard maps.
- With the participation of community members, the development of functional and detailed networks of escape routes and safety zones for evacuation.
- Emphasis on the necessity of future land-use changes and identification of the safe habitable areas, by using the hazard maps.
- Consideration for safe evacuation that can enhance the safety standards of coastal communities in an emergency situation for protection from tsunamis and other risks associated with coastal hazards. For example, the use of local high-rise buildings, such as hotels, for quick vertical evacuation.

6. CURRENT DISASTER MITIGATION SYSTEM AND PUBLIC WARNING PROGRAMS FOR TSUNAMI HAZARDS

A public warning system has the responsibility to properly identify a hazard, to assess its potential risk to vulnerable communities, and to issue a warning in a timely fashion so that measures of

protection can be taken and evacuation to designated safe areas. The accurate identification of the vulnerability of a population at risk, and finally the communication of information about the threat in sufficient time and clarity, is needed so that action can be taken to avert the negative consequences, constitute an effective system of public warning. The warning allows people to act to respond and to prevent hazards from becoming disasters. Effective public warning saves lives, reduces economic loss, reduces trauma and disruption in society, and instills confidence and a sense of security in the public. It is an important component of the foundation of a sound economy. Effective warning is just one of the critical parts of a comprehensive risk management system that includes mitigation, preparedness, response, and recovery. A warning is a crucial component of the overall risk management system that did not exist when the 2004 Indian Ocean tsunami struck. [5]

6.1. National Level

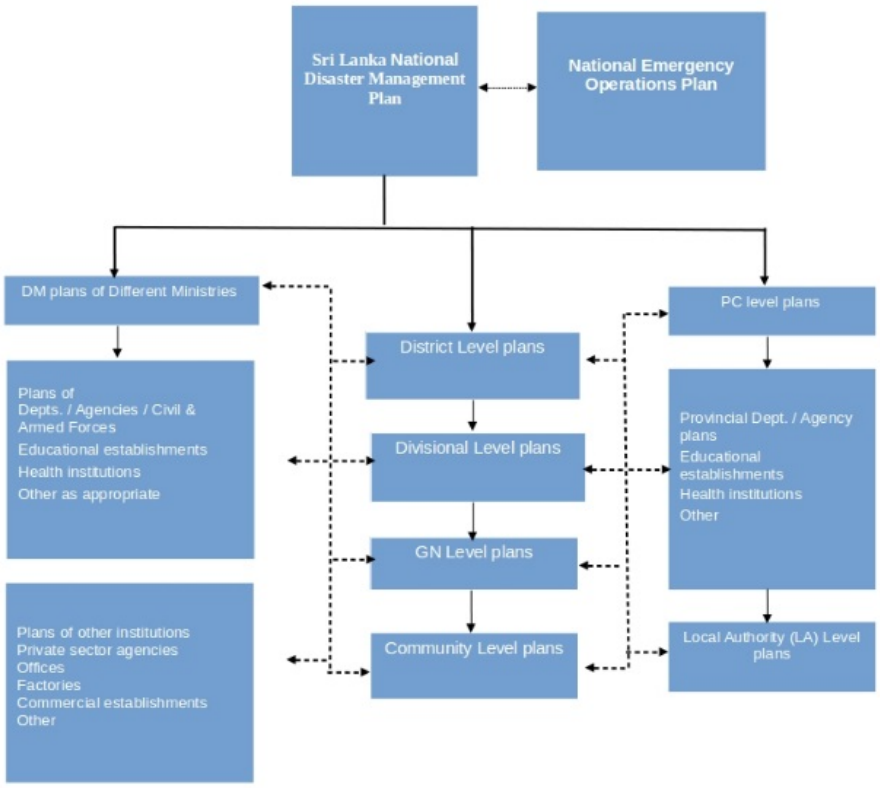


Fig. 3. Conformity of disaster management plans at all levels and in all sectors.
(Source: http://www.dmc.gov.lk)

As shown in the organizational diagram (Fig. 3),the Disaster Management Centre controls disaster relevant activities. It is the leading agency for disaster management in Sri Lanka. It is mandated with the responsibility of implementing and coordinating national and sub-national level programs for reducing the risk of disasters with the participation of all relevant stakeholders.

The main activities of DMC are Research and Development, Mitigation, Planning Preparedness, Dissemination of Early Warning for the vulnerable population, Emergency Response, Coordination of Relief, and Post Disaster Activities in collaboration with other key agencies.

To facilitate the coordination and implement all DMC activities, Disaster Management Committees were established at District, Divisional, GN/village, across the country. Also, District Disaster Management Coordination Units (DDMCU) were established in all districts to carry out Disaster Risk Reduction (DRR) activities at the sub-national level. [5]

6.2. Communication Systems for Early Warning Disseminations

The present system of communication from the national level to district/divisional/local authority/GN division levels or other specifically identified locations is mainly through the Police and military communication systems, radio communication, multi-hazard early warning towers, media, and the normal telephone systems. Alternative countrywide communication systems have already been established and with these improvements, DMC ensures that there will be a mechanism to inform the vulnerable communities immediately. These include the Nation-wide Emergency Communication System, which will be used to provide information, shown on this diagram.

IOTWS (Indian Ocean Tsunami warning and Mitigation System) is the main key warning centers for the Tsunami early warnings. INCOIS (Indian National Centre for Ocean Information Services), Aus. MET (Australia Meteorology) and the Indonesian MET departments are working together to send more technical information to the DMC and MET in Sri Lanka. Several Methods were integrated with an early warning system from the national level up to grass root level. EOC (Emergency Operation Centre) was strengthened with Police and tri-force units at the national level with their co-education equipment. [5]

6.3. Early Warning System Introduced by the Disaster Management Centre

The disaster management centre has introduced the steps listed below (see Figures 4, 5, 6)
- Maintaining and operating Early Warning Towers and other early warning dissemination equipment.
- Dissemination of Early Warning Messages and ensure the receipt at remote vulnerable villagers.
- Co-ordination of donor assistance to strengthen the capacity of technical agencies for early warning.
- Working out strategy and policy in the given area of activity.
- Initiating awareness on activities related to early warning among the various agencies and public.
- Guiding District Disaster Management Units in coordinating and implementing warning dissemination related activities in the Province, District, Local Authority, Division, GN level/village, and community level. [5]

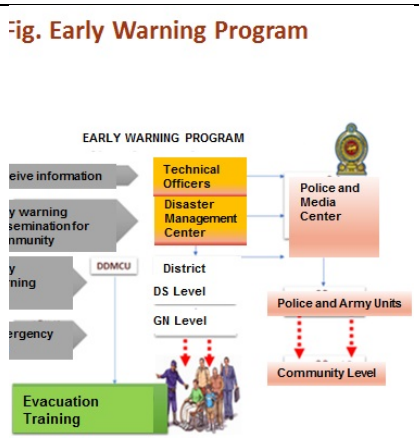
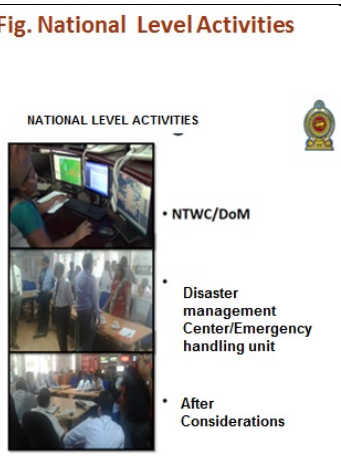
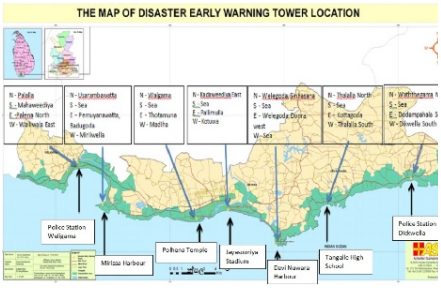
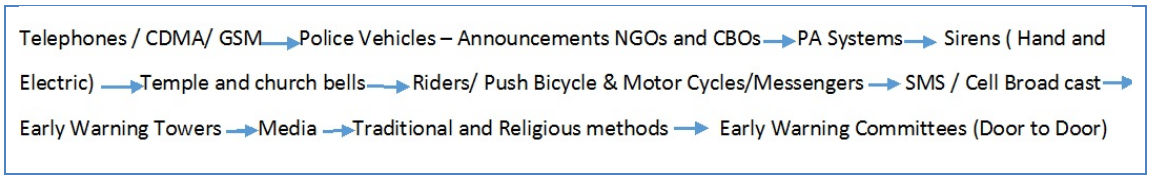
		

Fig. 4. Early Warning Program	Fig. 5. National level activities	Fig. 6. Locations of early warning towers on Southern Coast line

6.4.Community Level Communication Systems and Last-mile Dissemination

At the community level, emergency communication system by DMCwhich will be used, will provide the early warning information as shown on the following diagram.



Furthermore, from the all locations (district/divisional/local authority/GN levels or other identified specific locations) onwards, the dissemination to the communities is effected through the following various methods: Personnel and agencies such as Local authority officials, GN's, Local Police, CBO's, NGO's, Military, Police and Volunteers. All listed will be involved in the warning dissemination activities. The effectiveness of the methods will be different in different locations depending on the location-specific characteristics. [5]

7. EXISTING EVACUATION SYSTEM FOR MIRISSA GN DIVISION

7.1. Annual Evacuation Drills

According to the interviews conducted with community members and GN division head officers, ongoing evacuation procedures are as follows: By February 2019 the latest evacuation drill program had been conducted on 2018.08.20 at Mirissa GN division parallel to the National evacuation program for the coastline. The Disaster Management Unit of Matara District Secretary office conducted the Mirissa program.

A general announcement had been issued to the community before the drill. Evacuation warning had been disseminated by the areas' Tsunami tower siren, on the day. The community had started to evacuate to places/shelters, which they have been designated in general, such as high grounds/ hilltops, a school, and a temple (Fig.10). Evacuation routes and evacuation shelters had been decided randomly by some evacuees during the drill, as they had less awareness of the systematic evacuation route/ shelter guidance at the community level.

Fig.7. Existing Unsafe Communities and Unsafe Houses on Mirissa Coastline

3.1. Shortcomings of the Existing Evacuation System

Shortcomings in the evacuation include insufficient knowledge by a community to receive sufficient understanding of when and where its citizens need to evacuate for safety. Another shortcoming involves a community's difficulties in selecting evacuation shelters and routes, even after the participation in several evacuation drills. Part of the difficulty is to find a significant improvement of evacuation time based on a repeat of the 2004 tsunami disaster. (Fig.11. & Table-1.) Further community participation in evacuation activities is still very low at present time and more active participation in community evacuation programs is needed, such as in developing hazard maps, designating evacuation routes and other steps that need to be taken (Table-1.) The proposed evacuation map is tentative and presents difficulties, and it does not include detailed information on evacuation routes and places/shelters –all needed for a clear idea on safe evacuation. (Fig. 8.)

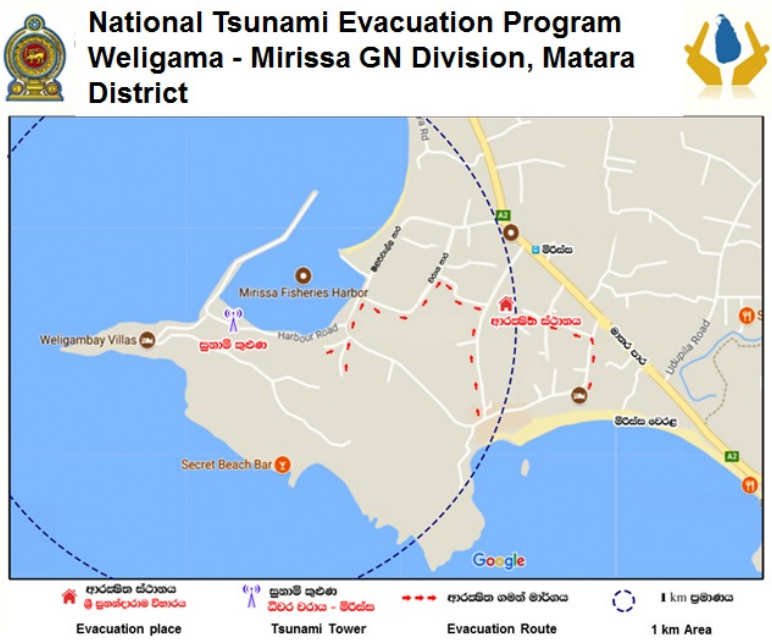


Fig. 8. Proposed Tentative Evacuation Route map for Mirissa GN Division
Source: Disaster Management Center –Matara District Secretarial Office

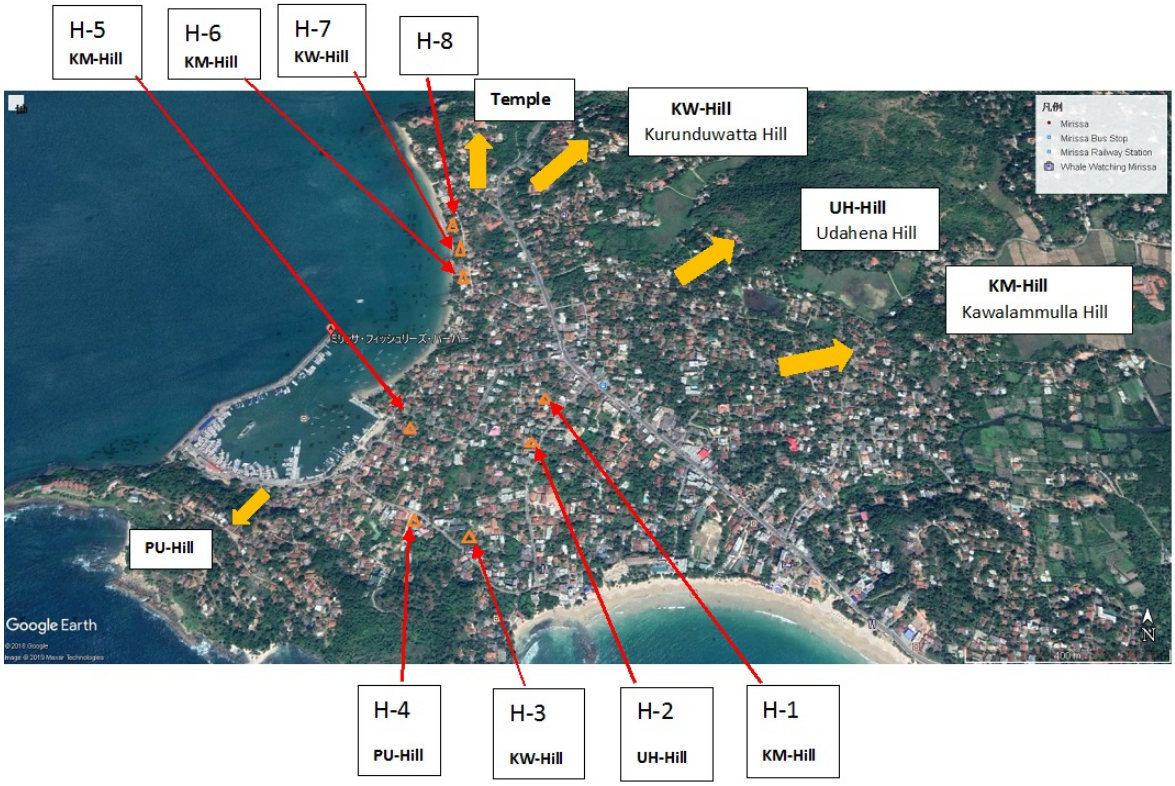


Fig.9. Locations of Interviewed Houses and Evacuated Places

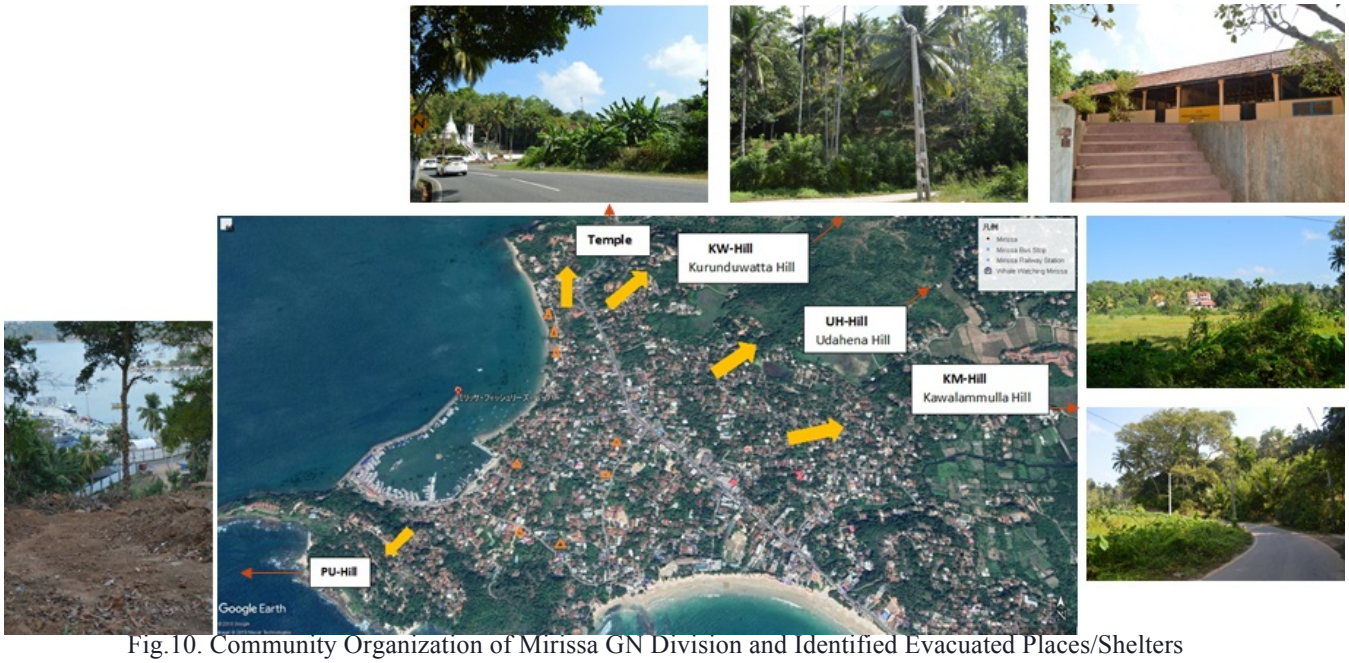


Fig.10. Community Organization of Mirissa GN Division and Identified Evacuated Places/Shelters

	H-1 65yrs/F	H-2 60yrs/F	H-3 55yrs/F	H-4 58/F	H-5 50/M	H-6 35/F	H-7 61/F	H-8 52/F
om Sea	300m	300m	300m	200m	100m	35m	35m	35m
s by mi	No	Housing & Property loss	Housing & Property loss	Property loss	Housing & Property loss	Housing & Property loss	Housing& Property loss	Housing& Property loss
using	No loss-covered property	Minor damages/6 m flood	Minor damages/ 6m flood	Minor damages/6 m flood	Partially Damaged	Partially Damaged	Partially Damaged	Partially Damaged
Place	KM-Hill	UH-Hill	KW-Hill	PU-Hill	KM-Hill	KM-Hill	KW-Hill	Unattended
elect	Just followed others	Own decision	Just followed others	Just followed others	Just followed others	Just followed others	Own decision	-
	No specific	No specific	No specific	No specific	No specific	No specific	No specific	-
ch to Place	About	About	About	About	About	About	About	About
ami on drill	15 min 15 min	30 min 30 min	20min/bus 30 min	15min/run 30 min	45 min 40 min	40 min 30 min	20 min 20 min	- 10 min
other later	No	Yes Temple	Yes Temple	No	No	No	No	No
dren/	Didn't support	Cuddle children	Didn't support	Didn't support	Didn't support	Didn't support	Didn't support	-
Stuff	No	No	No	No	No	No	No	-
of ami	Yes	Yes	Yes	No	No	No	No	Yes
under on	No children	Yes By School	No children	No children	No children	Younger children	Younger grand children	No children
uation ture	Same place	Temple (not sure)	Same place	Temple (un-confident/ 40 mints)	Same place	Same place	Temple	Temple (not sure)
map ated in	Haven't	Haven't	Haven't	Haven't	Haven't	Haven't	Haven't	Haven't
work	No	No	No	No	No	No	No	No
on	yes	yes	yes	yes	yes	yes	yes	yes
on of Drill	2 times	no	2,3 times	4 times	3,4 times	2 times	2,3 times	1,2 times

Table-1. Questionnaire Summary

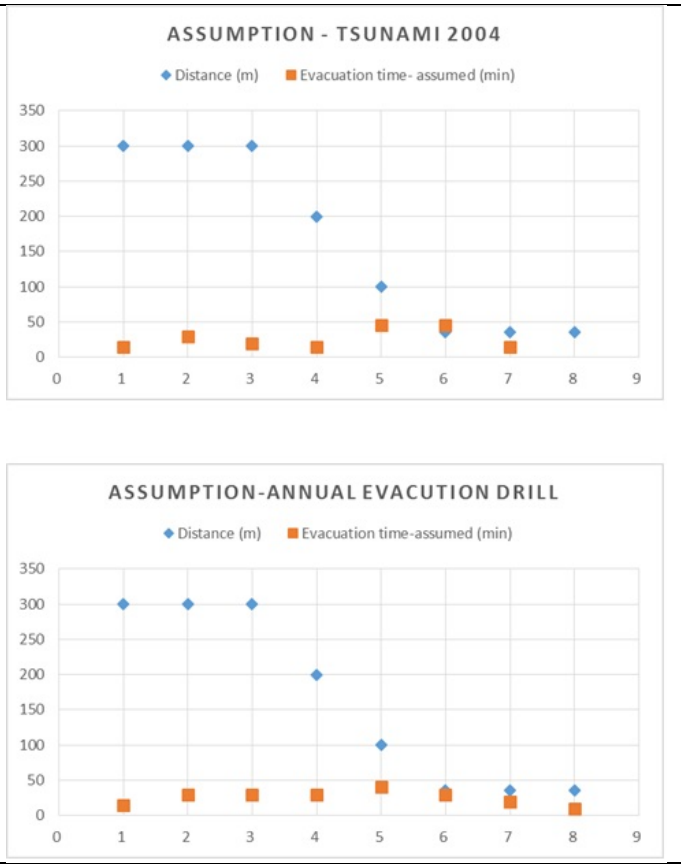


Fig.11. Comparison of Evacuation Time and Distance to Evacuation Shelter/Place.

4. CONSIDERATIONS AND RECOMMENDATIONS

4.1. Suggestions for Top-level Administration

To emphasize the importance of obtaining advance knowledge on the future possible risk and variations of risk-levels by earthquakes and Tsunamis for top-level decision-makers, due to unpredictable source regions of active seismic faults. It would be helpful for administrators to conduct risk assessments and evacuations programs in a more accurate and active manner, considering hazard-levels and safe evacuation times, particularly for coastline communities.

It is important to increase each community's awareness of the future Tsunami risk and of the procedures for safe evacuation. This could be achieved by increasing the understanding of potential risk areas, of methods for disaster mitigation and with the adoption of proper educational programs, for each vulnerable community.

4.2. Suggestions for Community-level Administration

The present study identifies the necessity for strategic evacuation plans/programs, and suggests the reconsideration of the existing programs, to properly addresses all safety/DRR aspects. Such plans should be ready to be in action in a short time, and with affordable, long-term and fruitful solutions for coastal communities.

4.3. How to Develop a Strategic Evacuation Plan/Program at the Community-level

It could be accomplished by community-level Hazard Mapping and by developing functional networks of evacuation routes to proper evacuation shelters/places. Active community participation should include educational programs for school children, as this is important for them to individually recognize their risk and what they need to do for their own safety.

It is important to consider the following recommendations in re-considering the existing programs and plans as summarized in Figure 12:

1. Introduction of best evacuation place at household level in each community.
2. Introduction of additional long-distance and short-distance escape routes and evacuation shelters at a community-level.
3. Identification of existing Tsunami resistant buildings at the community-level for emergency evacuation.
4. Increase community responsibilities and participation through community member leaderships and involvement of school children and for help of disabled persons/children, and other vulnerable groups.

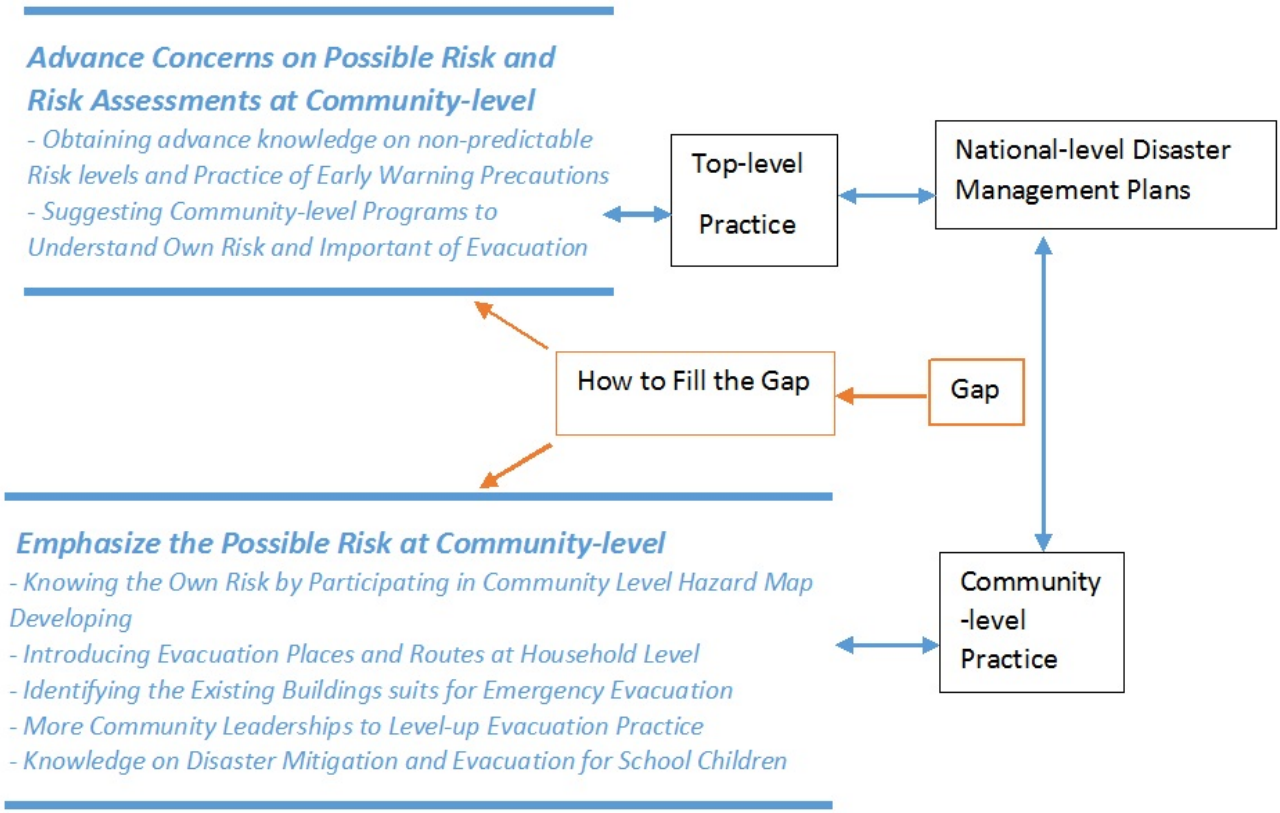


Fig.12. Consideration and Recommendation Summary Chart

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Notes: Acronyms

DMC - Disaster Management Centre

GN division - *Grama Niladari* division-Village officer division of Sri Lanka

GS division - District Secretariat division

DRR - Disaster Risk Reduction

IOTWS - Indian Ocean Tsunami Warning and Mitigation System

INCOIS - Indian National Centre for Ocean Information Services

EOC - Emergency Operation Centre