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TSUNAMI RISK MITIGATION THROUGH STRATEGIC LAND-USE PLANNING AND EVACUATION PROCEDURES FOR COASTAL COMMUNITIES IN SRI LANKA

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ABSTRACT

Safety measures against the future disaster risk are considered as the main aspect of post disaster reconstructions. The majority of post-disaster villages/settlements and due projects on Sri Lankan coastline are apparently lacking behind the proper safety measures and adequate evacuation procedures. Therefore the immediate necessities of proper safety measures have to be emphasized in order to mitigate future tsunami risks. This paper introduces a number of post disaster coastal villages/settlements, which are in future coastline hazard risk, mainly in a future tsunami event. These include their location risk, land uses and housing designs defects and shortcomings of other safety measures. Furthermore few tsunami risk mitigation measures through land use planning strategies, which could be applied more easily in community level, are introduced. In addition to those the strategic development methods of functional networks of evacuation routes and shelters in different topographies are examined.

Keywords: *Tsunami Risk Mitigation, Coastal Communities, Strategic Land-use Planning, Evacuation Routes, Vertical Evacuation Shelter*

1. INTRODUCTION

Dealing with tsunami risk mitigation measures is a relatively complex task. Tsunamis may extremely destructive in unexpected occasions although they are considered as infrequent events. That non-neglectful destructiveness and vulnerability was demonstrated in 2004 Sumatra earthquake and tsunami[1] by claiming more than 35,000 peoples' lives and affecting two thirds of the entire Sri Lankan coastline. Affected coastal area stretching over 1,000 kilometers and approximately 80,000 houses were completely destroyed and more than 40,000 partially impacted (ADB, 2005). Since then a number of post disaster reconstruction projects[2] have been implemented by the Sri Lankan government and many other national and international organizations still on the process of re building those affected coastal communities.

Although safety measures against the future disaster risk are considered as the main aspect of post disaster reconstructions, majority of the post-disaster villages/settlements in southern coastline have been established without proper safety measures or adequate evacuation procedures. Most of the ongoing coastline projects have being repeating the past mistakes of unsafe planning and construction. At the same time new residential areas which are yet to be planned for northern and eastern coast line communities are at risk due to lack of procedures of safety planning and building guide lines.

Those problems have easily been identified during our field visit at the most affected areas, dated from 07/08/2010 to 16/08/2010. Such mistakes may increase the susceptibility of coastal communities to unprecedented, extensive damages in such event of future natural disasters, hence immediate solutions are required. It seemed that lack of experience and information on handling the post-tsunami situations, unavailability of proper disaster resistant construction and land use planning guide lines have become the critical factors. Failure to implement such obvious safety aspects can never be justified for not being able to plan reasonably and practically, as such issues have been highly disadvantageous for the post disaster reconstruction process in Sri Lanka. Inclusion of DRR (Disaster Risk Reduction) as an integral element in every phase of planning for reconstruction and combination of community and living environment development proposals within the context of safety planning have now become the major challenges in the field of post disaster reconstructions in the country.

2. OBJECTIVES

The main objective of this study is to achieve the research targets of developing a comprehensive strategic plan compiles all components of the planning which extensively addresses such safety planning and evacuation procedures for Sri Lankan coast line and creating a combination of community and living environment development proposals within the context of safety planning.

To introduce a number of post disaster coastal villages/settlements, which are at future tsunami risk including their location risk, land uses and housing designs defects and shortcomings of other safety measures.

To propose few tsunami risk mitigation measures through land use planning strategies, which could be applied in community/village level more easily.

3. IMPORTANT OF PLANNING IN DRR

Planning as a process is inevitable in a reconstruction scenario, whether the decision is to just rebuild houses or to achieve comprehensive development resilient to the future disasters (World Bank 2010)*. On the implementation, the detail level of planning process and enabling or impeding of planning in reconstruction process will become major issues in future disaster events. The correct planning processes consider DRR for organizing housing and infrastructure reconstruction, addressing the impacts of the disaster and disaster risk reduction.

Further post disaster planning provides an opportunity to modify existing policies, inappropriate/unsafe legislation and regulations, strengthening institutions and improving construction methods as the basis of reconstruction forms by laws, regulations, plans and institutional frameworks.

3.1. Current Land Use Planning and Necessity of Proper Land Use Changes

It is hard to identify the proper DRR guidelines or clarification of disaster vulnerable zones in National Physical Planning Guidance or in the latest report of National Physical Planning on "Land Use Changes That Have to Taken Place in Sri Lanka" in year 2001**. The problems which could be risen up through inadequate planning guidance such as difficulties in identification of low risk zones for site selection, propose of appropriate structural designs due to inundation risk levels have been come across in most of the project planning and implementations. Those problems have been identified through several official visits by the relevant government authorities[3]. Further the unclear view of coastal communities regarding the safe areas and evacuation routes were identified through number of interviews.

Such insufficient considerations of coast line natural hazards and unavailability of risk mapping in comprehensive land use planning system in Sri Lanka emphasis the necessity of appropriate plans that follow tsunami readiness. The incorporation of zoning laws which guides for safe relocation for the existing system considering tsunami risk simulations and inundation levels will be more functional.

3.2. Village/Community Level Strategic Land-use Planning and its Importance

Fig.1. Introduction of Village/Community Level Strategic Land-use Planning

We suggest that the strategic land use planning which properly addresses DRR aspects and ready to place in action in a short time period as the best, simple, affordable, local and long term solution for Sri Lankan coastal areas. It offers a fruitful approach in complex task of tsunami risk mitigation measures more easily for the existing coastal villages/settlements and for the areas to be developed along with few moderations.

Comprehensive Land use plan addresses the overall and long-term issues of the community and establish a framework for the physical development of a region, municipality, city or village. In this study comprehensive planning is defined as a planning process that incorporates land use planning and physical planning. In this paper we focus on village and community level strategic land-use planning which comes under land-use planning and development of tsunami risk mitigation measures only. (Fig.1)

4. TSUNAMI RISK MITIGATION MEASURES

Land-use changes, relocation, development of water barriers, elevated sites and evacuation routes and shelters have been introduced as main tsunami risk mitigation measures though land-use planning in this paper.

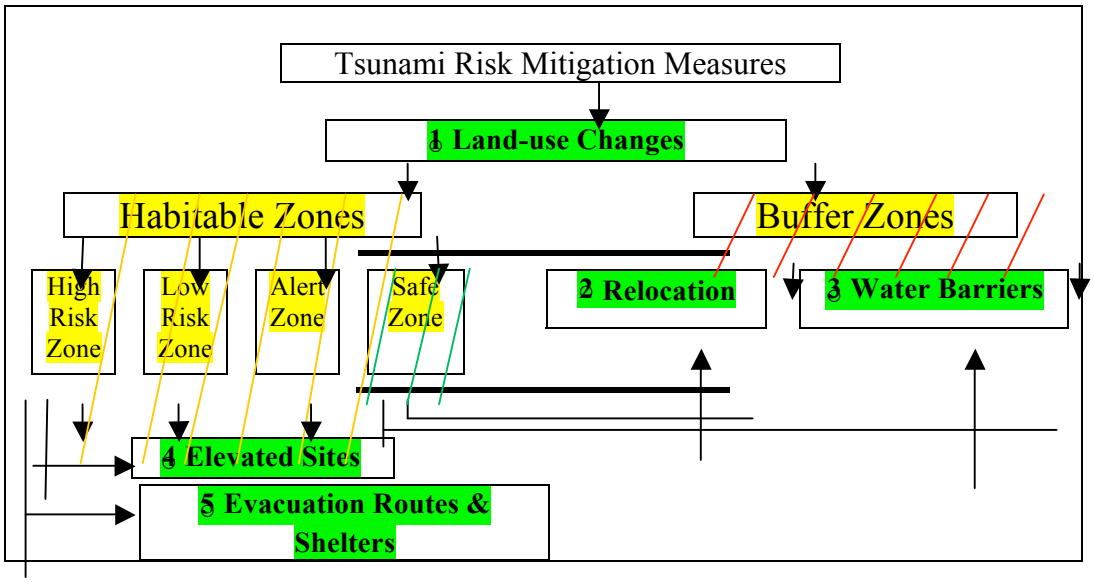

Fig. 2. Tsunami Risk Mitigation Measures

4.1. Introduction of DRR Land-use Changes to Existing Land-use planning

4.1.1. Introduction of accurate tsunami resist and non resist areas (Habitable Zones and Buffer Zones)

Although a Buffer Zone regulation[4] with construction restrictions has been introduced to cost line it does not seem to be working effectively in most of the areas as the reconstruction of permanent or

temporary shelters of tourist industry owners/ fishery community, etc. can be seen. Further many buildings projects has not been in accordance with the current tsunami resistant structural considerations, designs etc. and many yet to be constructed even in buffer zone through especial construction permissions and exemptions for tourist industry promoters while non-existence situation of planning or building guide lines.

On the other hand buffer zone regulation was not originally for demarcate a tsunami hazard zone, but for the conservation of coastal environment enacted by Coastal Conservation Department (CCD)*** which depicts the shortcomings of insufficient assessments of past tsunami hazards or estimation of future ones during its enactment.

It is suggested that following steps will be helpful to identify more accurate habitable safe coastal areas (Habitable Coastal Zone), and non-habitable unsafe coastal areas (Buffer Zone).

a- Estimate of inundation; Through an assessments of past inundated areas and projection/simulation of future inundation areas
b- Assessment of damage; Through an assessments of damage by past tsunamis and projection/simulation of damage by future tsunamis
c- Assessment of current levels of tsunami preparedness

4.1.1.1. Habitable Coastal Zone

a.) Minor Zoning through a risk assessment
Safety can be ensured by conducting a minor zoning in accordance with High Risk Zone, Low Risk Zone, Alert Zones and Safe Zone, which can facilitate in establishing early warning system and evacuation procedures.
b.) Promotion of Strategic Area Arrangements
The future risk can be mitigated through strategic area arrangements in habitable zones. Ex. Movement of Residential/Commercial areas to Low risk zones and Manufacturing/ Marine areas to High-risk zones.

4.1.1.2. Buffer Zone

The buffer zones can be used as barrier areas by developing artificial water barriers (wall) or natural water barriers (green belt).

4.2. Relocation

Relocation at every possibility is the most safest and economical measure which could be applied for the communities in high risk or buffer zones. It can be a tough job but still practical enough to counter post relocation problems, if proper planning including prior identification of safe zones is achieved.

4.2.1. Post Relocation Problems

We could identify number of post relocation problems in southern coastline as follows.

- Unavailability of future disaster responses; the relocation sites that have been selected without proper risk assessment or simulation can still have future disaster risk.

- Livelihood problems; mainly the fishery community is facing the livelihood problems due to the lottery system followed by the authorities for the distribution of permanent houses other than distance level, prior to livelihoods. This has caused returning to unsafe temporary shelters in coastline.

- Reluctance of distance living and return; disappearances of original community order, unwillingness or mental trauma to settle in a completely different inland settlement were the other main reasons for the reluctance of beneficiaries to settle in a distance relocation settlement and return to coastline except the livelihood problems.

- Inability of creating harmony with existing environment; many reconstructions of the permanent housing have not yet been able to act together with existing regional or local patterns and quality, thus creating the conflicts and gaps between the inhabitants and new comers.

4.2.2. Considerations in Relocation

Safe site selection due to a proper risk assessment or simulation method, Site selection prior to livelihoods, Preservation of the maximum original communities' order in new settlements, Keeping harmony with existing settlements, Active participation of beneficiaries, in relocation process could be effective to establish more safe, strong and long term relocated communities.

4.3. Physical Water Barriers

Protection of existing natural water barriers such as sand dunes and green belts or creation of those could minimize the impact and inundation level of tsunamis.

Fig. 3.Disturbed Natural Sand-dunes in Hambantota District

4.4. Elevated Sites for Constructions

Creation of elevated sites for constructions in high economically valued or essential land areas could reduce the effect of tsunami waves in future events.

4.5. Functional Networks of Evacuation Routes, Vertical Evacuation Shelters and Existing Safe Escape Places

Since evacuation is one of the most important codes in the disaster occasions, developing functional networks of evacuation routes, vertical evacuation shelters and identification of existing safe escape places are highly necessitated. On the other hand development of evacuation routes will lead proper access to the areas while construction of vertical evacuation shelters leads to public facilities development with strategic building proposals such as shopping complex, community centers, cultural centers, observation towers. Furthermore these kinds of development proposals lead to combine community and living environment development proposals within the context of safety planning.

a.) Use of Zoning: Use of zoning in proposed warning levels could be more systematic.

b.) Establishment of easy, understandable short and long distance evacuation shelters with escape routes in community and GN Division[5] level: The aspect of developing the evacuation route network should be coherent with proper evacuation sites, designation of evacuation routes, distribution of evacuation sites, location of evacuation routes, topography of evacuation sites, evacuee capacity, evacuation areas (including their relationship to residential zones), evacuation site structures, readying the approach routes, road width, potential problem spots (bridges, tunnels, etc.) In addition an evaluation of the evacuation feasibility of sites and routes should be done.

c.) Identification of existing tsunami resistant buildings: Community level pre introduction of each building could be more favorable in a disaster occasion.

5. DEVELOPING FUNCTIONAL NETWORKS OF ESCAPE ROUTES AND VERTICAL EVACUATION SHELTERS FOR SELECTED CASES ON SOUTHERN COASTLINE OF SRI LANKA

We have selected three coastline reconstructed housing settlements (case 1, 2 and 3) and one original community (case 4) which are in future tsunami risks as per the case studies. In this study we have attempted to observe the location/topographic risk and evaluate the proposed zoning, warning levels, evacuation modes, evacuation routes and evacuation shelters accordingly.

Zoning has been done by considering only past records of inundation levels and interviews with community members. Warning levels, evacuation modes, evacuation routes and evacuation shelters have been proposed with the use of site visits records, interviews with community members andGoogle earth maps[6] only.

Fig. 4. Locations of Case Studies

Table 1: Development of Functional Network of Evacuation Procedures for Selected Cases in Southern Coastline of Sri Lanka.

Tasks		**Case 1** French Village	**Case 2** Pelena Housing	**Case 3** Thotamuna & Polhena	**Case 4** Mirissa Harbor area
A.) **A.) Zoning** 1. High Risk Zone (FWL) (for this study 0-500m)		Highly demands (risky topography)		Highly demands (risky topography & high dense area)	
2. Low Risk Zone (FWL) (for this study 500-1000m)		critical	difficult to demarcate	easy to demarcate	
3. Alert Zone (FWL & SWL) (for this study 0-200m)		river banks		river banks	Not found
4. Safe Zone (SWL) (for this study 1000m~)		average time to reach	long time to reach	short time to reach	average time to reach
B.) Warning Levels 1. First Warning Level –FWL		- People in High Risk Zone and Alert Zone should be evacuated to Low Risk Zone or safe vertical shelters - People in Low Risk Zone should be evacuated to Safe Zone or safe vertical shelters			
2. Special Warning Level –SWL		- People in Safe Zone should be evacuated to safe vertical shelters			
C.) Evacuation Modes	High Risk Zone	On foot			
	Low Risk Zone				
	Alert Zone				
	Safe Zone	Vehicles allow			
D.) Evacuation Routes		- clear directions with sign boards - pre defined routes at every possibility - Alternative roads for alert areas and risky points (river banks, bridges, etc.)			

E.) Evacuation Shelters	High Risk Zone	- need future construction proposals: Tsunami resistant multi storied buildings within short distances
	Low Risk Zone	- use of existing buildings: Appropriate buildings such as community centers, hotels, schools, etc.

5.1 Case 1-French Garden Village-Galle District

Living environment, housing arrangement and location of the settlement 1:200	Views of the widely pen sea front of the settlement	Reconstructed unsafe single storied houses in the settlement

Fig. 5: Surrounding and Inside Views of the Reconstructed "French Garden Village" Housing Settlement

The location risk could be identified due to wide-open sea front and adjacent river without any tsunami wave breakers. The non tsunami resistant single storied houses and unavailability of adequate evacuation routes and shelters can certainly increase the affects of future tsunamis. Proposal of zoning and evacuation routes and shelters development for the communities of Kataluwa area are shown in Fig. 6.

Fig. 6: Proposal of Zoning, Evacuation Routes and Shelters for "French Garden Village" and Surrounding Communities in Kataluwa-west GN Division, Galle District.

5.2 Case 2-Pelena Solidealstar Village-Galle District

Living Environment, housing arrangement and location of the settlement, Scale: 1:200	Views of two storied houses and community center in the settlement	Two storied houses adjacent to fully damaged houses

Fig.7: Surrounding and Inside Views of the Reconstructed "Pelena Solidealstar Village" Housing Settlement

Fig. 8: Proposal of Zoning, Evacuation Routes and Shelters for "Pelena Solidealstar Village" and Surrounding Communities in Pelena GN Division, Galle District.

The Pelena Housing settlement and other surrounding communities are in a risk location due to the adjacent sea and river, without sufficient water barriers in a future tsunami. It has been attempted to mitigate the future effect by constructing reinforced two-storied housing but still a considerable amount of risk remains due to design problems related to creating proper safe places. Furthermore unavailability of adequate evacuation routes and shelters has increased the disastrous effects of

tsunami in a future event. Fig. 8 shows the proposals for zoning and development of evacuation routes and shelters for the communities of Pelena area.

5.3 Case 3-Thotamuna and Polhena Owner Driven Housing Project-Matara District

In the areas of Polhena and Thotamuna, which were severely affected by the last tsunami, some reconstructed multi storied houses with pillar structures can be found as a tsunami risk mitigation method (Fig. 9). Existence of famous recreation beach and fish market which make the area crowded in daily life emphasize the necessity of efficient evacuation routes and shelters in a future disaster occasion. The proposal for zoning and evacuation routes and shelters development is shown in Fig.10

Living environment, housing arrangement and location of Thotamuna 1:200	Reconstructed three and two storied houses in the affected villages	Living Environment, housing arrangement and location of Polhena 1:200

Fig. 9: Views of the **"**Thotamuna and Polhena" Owner Driven Housing and Locations

Fig. 10: Proposal of Zoning, Evacuation Routes and Shelters for "Thotamuna and Polhena" Owner Driven Housing and Surrounding Communities in Thotamuna and Polhena GN Division, Matara District.

5.4 Case 4-Unsafe Coastal Housing in Mirissa-Matara District

Living Environment, housing arrangement and location of the housing area, Scale-1:200	Damaged houses by Sumatra tsunami 2004	One of the unsafe houses in the area; located about 40m from the sea

Fig. 11: Views of the Existing Unsafe Housing and Surrounding Area Adjacent to Mirissa Fishery Harbor

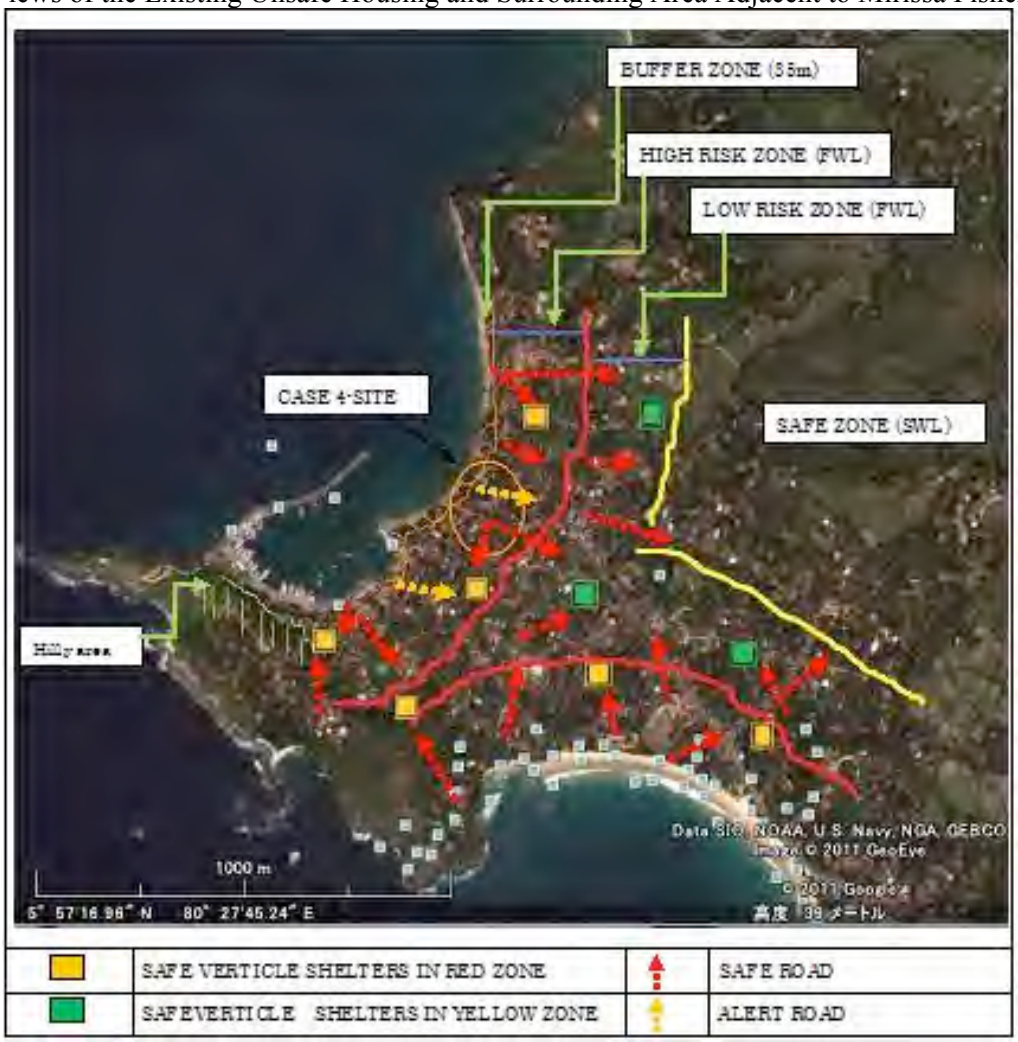

Fig. 12: Proposal of Zoning, Evacuation Routes and Shelters for Unsafe Housing Area Adjacent to Mirissa Fishery Harbor and Surrounding Communities in Mirissa-south GN Division, Matara District.

It is complicated to find any tsunami risk mitigation method adopted by the present coastline communities in Mirissa and surrounding areas, although extensive damages were recorded during the past tsunami. The buffer zone reduction up to 35m has remained the partially or non-affected houses at the coastline without proper protection or evacuation guidance. Fig.12 shows the proposals for zoning and development of evacuation routes and shelters in the area.

6. CONCLUSIONS

1. Changes of land-use planning which address DRR and combination of tsunami risk mitigation measures and safety evacuation procedures to the existing planning system will mitigate the future disaster risk and lead to more safe coastal communities.
2. The use of land and zoning laws, guidance for relocation to safer zones are in cooperation with the changes for the existing system, which considers tsunami risk simulations, and inundation levels could be more functional.
3. Strategic development of evacuation routes and vertical shelters will mitigate the future disaster risk while leading to a sound combination of the community and living environment development proposals within the context of safety planning.
4. There is a necessity of disaster mitigation management plans, which consider the topography of the each area.
5. A post disaster planning process, which incorporates active collaboration among the disaster mitigation agencies, all the reconstruction agencies consist with private sector, other stakeholders and the affected communities, leading to develop the safe and sustainable coastal communities.

Acknowledgements

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Notes

[1]The Sumatra earthquake and tsunami, with a magnitude 9.0, occurred at 7.58 AM on December 26th 2004 under the Indian Ocean. As a result of the earthquake and tsunami, in all affected regions more than 220,000 people died, making it one of the greatest natural disasters recorded.

[2]The introduction of buffer zone led to two types of post tsunami housing reconstruction programs. a; Home-owner Driven Housing Reconstruction Program for fully/partially damaged hoses outside the buffer zone.
The government of Sri Lanka is providing cash grant reimbursed by different redevelopment banks and bilateral donors to an affected homeowner for reconstruction of his/her house. b; Donor-driven Housing Reconstruction Program for relocate the affected families were in buffer-zone. All affected families are entitled to a house built by a donor agency in accordance with Government of Sri Lanka standards. The donor will provide each new settlement with an internal common infrastructure while Government of Sri Lanka provides the services up to the relocation site.

[3]UDA (Urban Development Authority, Colombo), NHDA (National Housing Development Authority, Colombo), NDMC (National Disaster Management Centre, Colombo), NBRO (National Building Research Organization, Colombo), District Secretariats in Galle, Matara and Hambantota districts, Sri Lanka.

[4]The buffer zone (or set-back-zone) was divided in to two parts as; Zone 1: 100 m landwards from the mean high waterline in the western, southern and southwestern districts. Zone 2: 200 m landwards from the mean high water line in the northern and eastern districts of Sri Lanka. The buffer zone has been a critical issue in the recovery process, which has not worked equally effectively in all areas. Later on it was reduced up to minimum of 35m and currently varies in-between 35m-200m.

[5]*Grama Niladari* (Village Officer) Division of Sri Lanka. Number of GN Divisions creates a DS Division (District Secretarial Division).

[6] Maps downloaded from websites of http://www.earth.google.com