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Rapid Vulnerability Assessment

in Sri Lanka

Jörn Birkmann, Nishara Fernando, Siri Hettige, et al.

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Rapid Vulnerability Assessment in Sri Lanka

Post-Tsunami Study of Two Cities: Galle and Batticaloa

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Table of Contents

Abstract

This UNU-EHS study deals with the development and testing of different methodologies to identify and measure the pre-existing and emergent vulnerability (revealed vulnerability) of coastal communities in Sri Lanka to tsunamis and coastal hazards. The results of the study show that females were more vulnerable to the tsunami than males. Single-storey buildings were more likely to collapse than multi-storey buildings (physical vulnerability), particularly in the first 100 meters from the sea. The likelihood of being killed in the first 100m from the sea was twice as high as in the 200m and 300m zones from the sea. Those who survived, needed loans to rebuild their properties and businesses. Friends, neighbours and relatives were mostly the source of loans; and not the formal banking sector. The study reveals that people and households in Batticaloa face greater difficulties recovering from losses than people and households in Galle. While, for example, around 25 percent of the households included in the survey in Galle need more than two years to replace their actual housing damage, the same category is nearer 60 percent in Batticaloa. This might also be a result of the devastating conflict in the region over the past 20 years.

This study not only provides new insights into the vulnerability of coastal communities and cities in Sri Lanka, it also gives an overview of different methodologies, in terms of their advantages and disadvantages, with regard to the identification, measurement and assessment of vulnerability.

In addition to its significant findings and policy recommendations the study provides in-depth information about different data sources that can be used to assess various characteristics of vulnerability. Methods of measuring the vulnerability of the built environment, critical infrastructures and social groups are shown. The project also aimed to strengthen the role and capacities of universities in disaster-hit countries in the reconstruction process, for example in developing methods to identify areas where support is most needed. The study was undertaken primarily in the city of Galle, and additional research was conducted in the city of Batticaloa. The report presents the results of a joint project, coordinated by UNU-EHS and involving the University of Colombo, the University of Ruhuna, the Eastern University, the German Space Agency and the Centre for Development Research (ZEF). The project received financial support from UN/ISDR-PPEW.

Introduction

The following study was conducted between May 2005 and January 2006. It aimed to define criteria and indicators to estimate and measure vulnerability at the local level to tsunamis in selected municipalities in Sri Lanka, as well as identifying various vulnerabilities, coping capacities and potential intervention tools. Moreover, the study focused on the advantages and disadvantages of different techniques to measure vulnerability. In this context four different methodologies and data sources were analysed. These included for example remote sensing to estimate the vulnerability of the built environment (physical vulnerability) and a questionnaire-based survey to assess major characteristics of the vulnerability of different social groups (socio-economic vulnerability).

In order to ensure high policy relevance for the research, the study also encompasses the analysis of intervention tools established after the Tsunami, for example by the Sri Lankan government to reduce vulnerability to future Tsunamis and coastal hazards, such as an early warning system or a 100m 'buffer zone'. In this context the study shows that a general 100m zone does not meet the specific requirements.

The results provide important conclusions, recommendations and incentives for a more sustainable reconstruction of the cities of Galle and Batticaloa, and for coastal communities in general. Furthermore, they give insights into how to identify and measure susceptibility, and the unusual difficulties different types of household have had in trying to recover. This analysis could be used in the future to define more precisely those households which need aid the most.

Finally, conclusions and recommendations are formulated which provide an important contribution to future disaster management, reconstruction and sustainable development of coastal communities in Sri Lanka. The findings and recommendations were discussed with country representatives, delegates and practitioners in various fields of disaster risk reduction and development, for example within a larger workshop in Colombo/Sri Lanka and in Bangkok at an international conference.

1 Rationale and Background to the Study

by J. Birkmann

The devastating tsunami in the Indian Ocean on 26 December 2004 hit Sri Lanka and Indonesia hardest. In Sri Lanka alone the tsunami affected more than 546,509 people – 3 percent of the total population – and around 40,000 people were killed or went missing as a result (Department of Census and Statistics 2005).

Although the vulnerability of coastal communities in Sri Lanka was highly visible in the tsunami catastrophe, issues of reconstruction, relocation and urban renewal are medium and long-term tasks, and they should promote more disaster-resilient communities in coastal areas. Therefore, the identification and understanding of different vulnerability patterns, coping capacities and intervention tools is a prerequisite to facilitating the reconstruction process with appropriate information to ensure sustainable development. The following results are based on a study currently undertaken in Sri Lanka to measure pre-existing and emergent vulnerabilities to tsunamis of coastal communities. This research is embedded in a larger project concerned with the strengthening of early warning capacities, which is supported financially by UNU-EHS and UN/ISDR-PPEW. The duration of the project was relatively short – less than one year – and was conducted within a difficult environment, that means people and institutions were still trying to recover.

As part of its mandate, UNU-EHS conducted research into vulnerability and human security in collaboration with universities, in both the Sinhalese and Tamil parts, of Sri Lanka in order to strengthen the local capacity and cooperation of scientific institutions and to facilitate the reconstruction process by providing essential scientific information. Moreover, UNU-EHS intended to strengthen the role of universities in the recovery and reconstruction process; and in future disaster risk reduction activities, such as the national plan for disaster reduction (short Road Map). In this context, a workshop in Colombo was organised to present the findings of the project and to bring together different stakeholders, such as the research community, disaster management institutions (Disaster Management Centre) and international organisations such as UN-OCHA and UNDP.

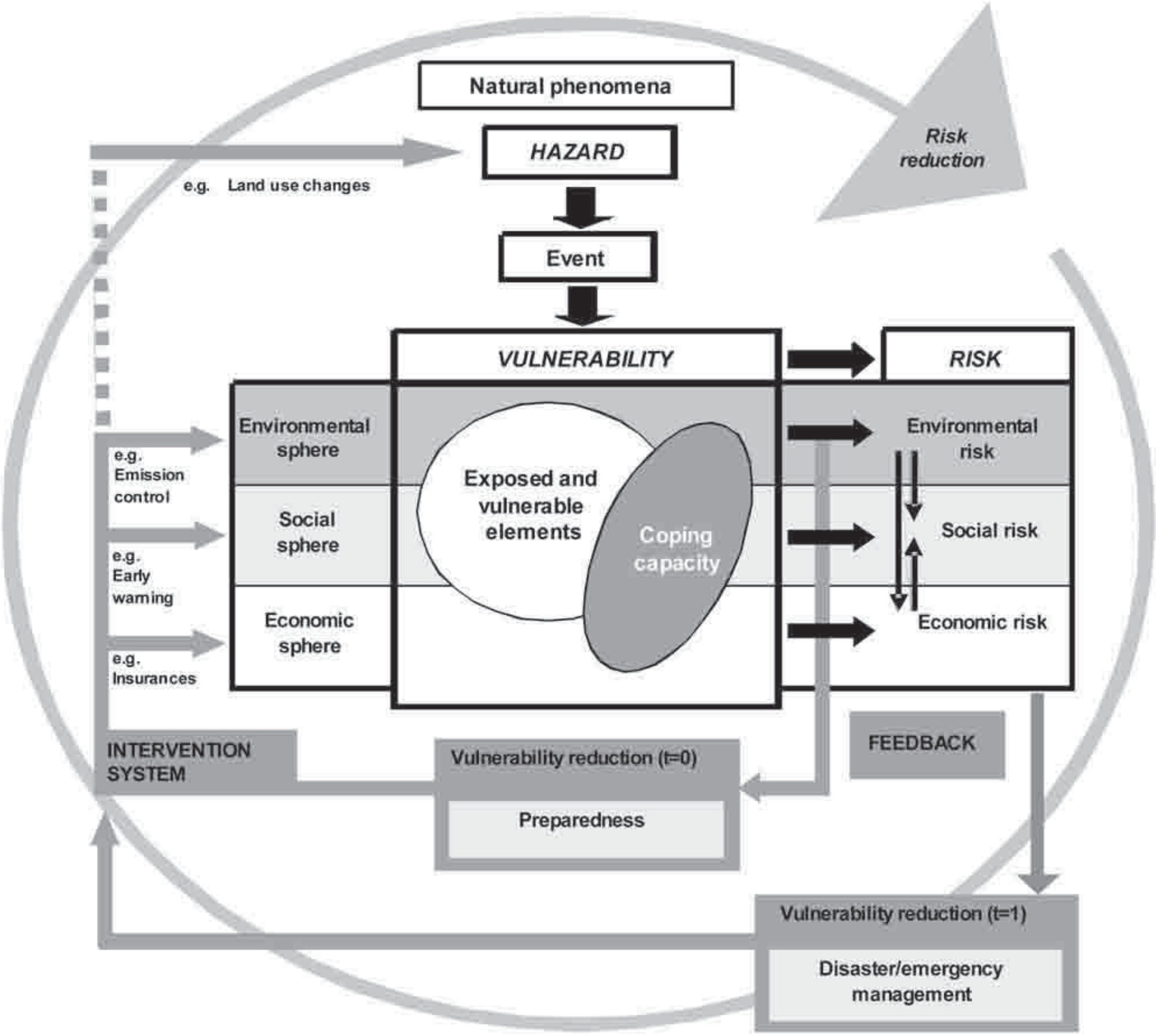
2 Overview of the Structure and Methodology

by J. Birkmann

2.1 The Conceptual Framework

The vulnerability assessment approaches that were developed and tested in this project aimed to explore various characteristics of the vulnerability of different social groups, basic infrastructure services and economic sectors to tsunamis and coastal hazards. At the same time, the research should also provide more in-depth knowledge of the advantages and disadvantages of the different methodologies in identifying and measuring vulnerability. As a theoretical framework and definition of vulnerability, the approach is based on the BBC-conceptual framework (see Figure 1), which stresses the fact that vulnerability is defined through exposed and susceptible elements on one hand, and the coping capacities of the affected entities (for example social groups) on the other. Moreover, the BBC-conceptual framework shows that it is also important to address the potential intervention tools that could help to reduce vulnerability in the social, economic and environmental spheres (Birkmann 2006). In contrast to other approaches the framework also underlines the necessity of integrating social, economic and environmental aspects into the vulnerability assessment. This clearly indicates the link between vulnerability assessment and sustainable development by taking into account the three pillars of sustainable development: the social, economic and environmental spheres.

Figure 1: The BBC-conceptual framework



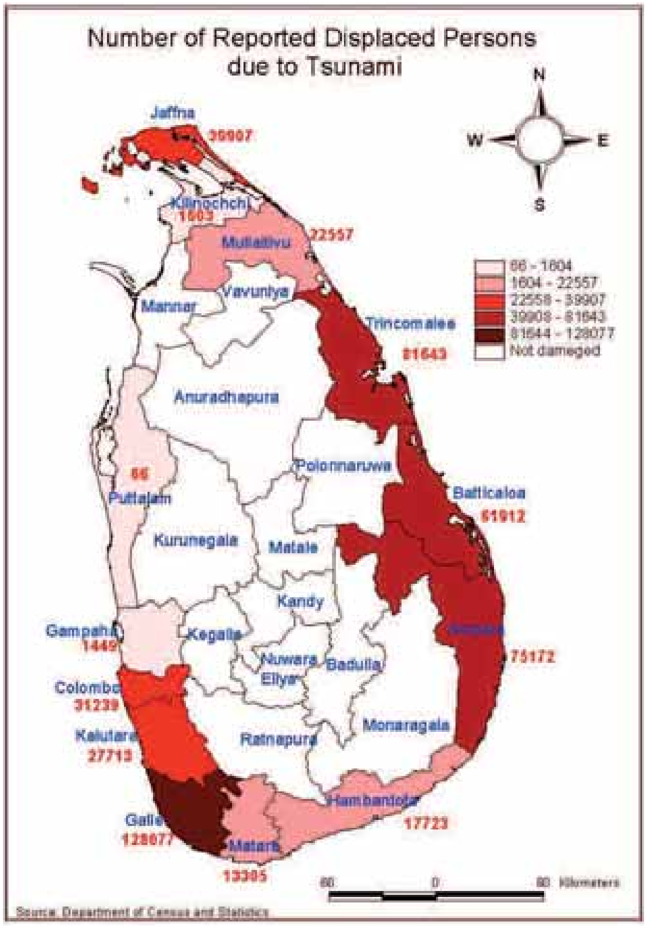
Source: Birkmann 2006, based on Bogardi/Birkmann (2004) and Cardona (1999/2001)

The BBC-framework was used to structure the assessment of the vulnerability of different social groups to tsunamis and coastal hazards using questionnaires as a data-gathering tool. In addition, the sustainable livelihood framework (DFID 1999) was used to structure and develop the social group analysis. Moreover, the ideas on how to assess coping capacity and particularly the capacity of poor people, e.g. through analyzing recovery processes and social networks, was also inspired by thoughts of Bohle (2001 and 2005) and Wisner (2002), who underline the importance of not just focusing on deficiencies but also on the abilities of different social groups in coping and recovering as part of vulnerability assessment.

The conceptual framework also gave guidance for the basic infrastructure and sector analysis, as well as the selection of appropriate census data in order to estimate the exposure of elements at risk, their susceptibility and coping capacities.

2.2 Selection of the Locations and Study Sites

Figure 2: Spatial distribution of the number of displaced persons due to the tsunami in Sri Lanka



Source: Nandana, based on data of the Department of Census and Statistics, Sri Lanka

In order to study various features and characteristics of vulnerability along with the impact on critical infrastructure it was decided to focus on the city of Galle – one of the municipalities hit hardest in the southern province – and the city of Batticaloa, in the eastern part of Sri Lanka, which still faces a low-intensity military conflict (Spiegel Online 2006; BBC 2006). Both Galle and Batticaloa were heavily affected by the tsunami, and were therefore important areas in which to study the revealed vulnerabilities within the tsunami in more depth. But they were also important for the study of coping capacities, rehabilitation and reconstruction in order to derive relevant indicators that best visualise and explain the vulnerabilities and particular difficulties in recovering from the December 2004 tsunami.

2.3 Research Methodology

Overall, the research encompassed four main techniques to identify, measure and assess vulnerabilities, coping capacities and appropriate intervention tools, focusing on different data sources and different characteristics of vulnerability (see Figure 3).

Figure 3: Overview of the four main techniques used to assess vulnerabilities

1) *Assessment of the built environment with remote sensing*
   Estimation of vulnerability of different urban areas
2) *Critical infrastructures and sectors vulnerability*
   Ground survey of the exposure and susceptibility of basic infrastructure services and their facilities, e.g. hospitals and schools
3) *Vulnerability of different social groups – questionnaire-based*
   Interviews with households in selected locations to identify and assess the different vulnerabilities of various social groups to tsunami risk. Focus group discussions, in-depth interviews with selected families and key informant interviews were also conducted.
4) *Vulnerability of social groups and local communities*
   Census data-based assessment of vulnerability using general indicators

1) The first methodology aimed to estimate the overall exposure of the settlement area and to examine some characteristics of the vulnerability of different city areas – GN (Grama Niladari) divisions, the smallest administrative unit in a Sri Lankan census – by looking at the structure and quality of the built environment. We think that the type of settlement and housing unit allows a classification of urban areas with regard to their socio-economic status. This means we assume that a community's higher or lower vulnerability can be associated with the conditions of the built environment different groups are living in. Thus, it was intended to test the ability of remote sensing to estimate socio-economic conditions as well. However, this analysis – especially the classification and automatic analysis of different housing types –proved to be more complicated than expected (see Chapter 3). The remote sensing methodology also allows for comparison of the situation before and after the tsunami, implying that one can analyse the extent to which the exposure and structure of the buildings were major causes of revealed losses. Therefore, we intended to implement remote sensing techniques to both, to measure physical vulnerability and to test how far this information can be used to estimate socio-economic aspects linked to vulnerability, such as poverty.
2) The second methodology explored the exposure and susceptibility of different critical infrastructures and sectors, such as education (e.g. schools), the health system (hospitals), finance/ banking (banks). In the first phase of the research conducted in Sri Lanka the main focus was on the degree of exposure of different units of critical infrastructures and sectors. The analysis clearly indicates that some infrastructures, such as hospitals, were highly exposed in the high-risk zone, implying that they were potentially more vulnerable than those infrastructures located primarily in the hinterland.
3) The third methodology required the most attention and included questionnaire-based interviews to explore the various vulnerabilities of different social groups in selected locations prone to tsunamis and coastal hazards in Galle and Batticaloa. Besides the analysis of the revealed vulnerability (pre-existing and emergent vulnerabilities), the structured questionnaire survey should allow for a better understanding of vulnerability after the tsunami (see Chapter 5). Also, qualitative methods such as semi-structured interviews and moderated focus group discussions were conducted with families and key informants (see Chapter 7). They were aiming at generating additional information to gain a better interpretation of the results of the questionnaire-based household survey.
4) The fourth methodology focused both on general indicators in the census and local statistics in order to estimate the vulnerability of different social groups and economic sectors of coastal communities to tsunamis and coastal hazards (see Chapter 9). This technique was also intending to use some of the indicators identified in methodologies mentioned earlier. This means that it should be tested whether some indicators and patterns of vulnerability identified at the household scale can be up-scaled by using census data for a whole city.

Overall, the research design was intending to identify and measure pre-existing and emergent vulnerabilities within a rapid vulnerability assessment – in other words, within a timeframe of eight months. Also, it was of scientific interest to test and compare different techniques and methodologies to identify and measure vulnerability.

3 Vulnerability Assessment of the Built Environment

by M. Naßl and S. Voigt

3.1 Introduction: Vulnerability Assessment Using Remote Sensing

In the field of vulnerability assessment remote sensing can still be considered a new tool, since more established approaches come from the socio-economic sector using statistical surveys to feed geographic information systems and derive spatially distributed vulnerability indicators. It is the scope of the work presented here to evaluate how satellite remote sensing techniques can complement such approaches.

Within this project it has also been tested whether remote sensing techniques can serve as a fast and possibly low-cost tool for vulnerability assessment when compared to more traditional census-based approaches. While these census-based methods are very labour-intensive and involve manual surveying and mapping of large surfaces, remote sensing-based approaches can reduce significantly the time needed for field surveys and assessments. However, remote sensing-based indicators also rely on some sort of ground reference information, such as political and cadastral units, and certain base parameters on the socio-economic structure of the studied area.

Generally speaking, remote sensing observations can provide fast and spatially referenced information, for example, on urban areas making use of multispectral optical satellite imagery. Figure 4, shows below a subsection of the city of Galle in February 2004, before the tsunami hit the area. This satellite image, taken by the IKONOS satellite, contains four spectral channels in, respectively, the blue, green, red and near infrared parts of the electromagnetic spectrum. Each channel was sharpened from the original 4-m resolution to 1-m resolution, using the high-resolution panchromatic channel of the satellite system.

Figure 4: The city of Galle, 20 February 2004: a selected coastal area

Source: M. Naßl and S. Voigt, data Ikonos

Figure 4 gives an example of the level of information detail that can be derived from 1-m satellite imagery, recorded from a 600 km orbit. A visual interpreter and analyst can easily identify objects and image features, such as water; sand/ beach; vegetation such as trees and bushes; houses of different shape, colour and size; streets; cars; and non-built-up areas (without houses, infrastructure or vegetation).

As can be seen from Figure 4, spectral features are the most prominent in helping to identify and separate objects in satellite imagery. However, certain spectral properties can be ambiguous and may be assigned to different object types. Therefore, further criteria are required for the identification of different image objects. In the case of houses, structural criteria such as texture, construction patterns and the existence of 'colinearity' can support the characterisation of urban structures. Vegetation also plays a major role in the analysis of levels of urbanisation and surface sealing. The near infrared channels of remote sensing systems are useful in delineating such vegetation features. It is obvious that the variability of such features within a given object class can be very wide. When analysis imagery is taken at different dates, under different illumination conditions, a certain object class may look completely different, thereby hampering an automatic detection by means of computer algorithms. Another important issue for analysis of remote sensing imagery – be it visual or automatic – is the contextual relations between image objects, such as the distance to each other and mutual orientation. All such features may be used to classify and analyse image objects. However, identifying a certain housing structure or urban feature is only the first step, since economic and social indicators of vulnerability cannot be directly identified in satellite imagery. Yet they can be derived indirectly from objects and their respective context, by linking, for example, urban objects with additional socio-economic characteristics such as information on income, or age structure of certain housing types. For some features it is more straightforward to assess their criticality with respect to a certain vulnerability. This applies with roads or railways, which can be identified and mapped from satellite imagery in a relatively easy way. However, the semantics of other critical infrastructural facilities, such as hospitals, schools and supermarkets, cannot directly be identified and mapped from satellite imagery without further ground reference information.

3.2 Methodology

Building on these considerations the following approaches to derive vulnerability indicators were adopted. The most appropriate vulnerability indicators for this study were defined, as well as the specific area of vulnerability to be analysed. For the assessment of settlement vulnerability, the individual location and structural properties of the urban area are expected to contribute the most to its physical vulnerability. Consequently, this study concentrates on these indicators and also considers the advantages and disadvantages of satellite-based remote sensing analysis. Basically, the methodological approach is divided into two steps: (1) image processing and analysis, and (2) the use of Geographic Information Systems (GIS) for further analysis and map generation. Image analysis is used for mapping the indicators through visual interpretation or automatic methods. GIS, on the other hand, stores the resulting geographically located information which can then be used to integrate information from other databases to derive the required vulnerability indicators.

Statistical background data was provided by the project partners at the University of Colombo, who collected 'in situ' reference data on the urban structures and features. In addition, the Remote Sensing and Geographic Information System Unit (RS/GIS Unit) of the International Water Management Institute (IWMI, www.iwmidsp.de) provided spatial data through its headquarters in Sri Lanka and regional offices in various parts of the world. Reference data and information on the tsunami's impact on the city of Galle could be obtained. Data sets on population density at city quarter level (GN level), both before and after the t sunami, as well as meta-information on settlement types and structures at quarter level, were provided by the University of Colombo and UNU-EHS.

Considering that the exposure of a given settlement plays a key role in vulnerability assessment in general, a first step towards the goal was the analysis of exposure parameters for the city of Galle with respect to the tsunamis hazard, as described in the following section.

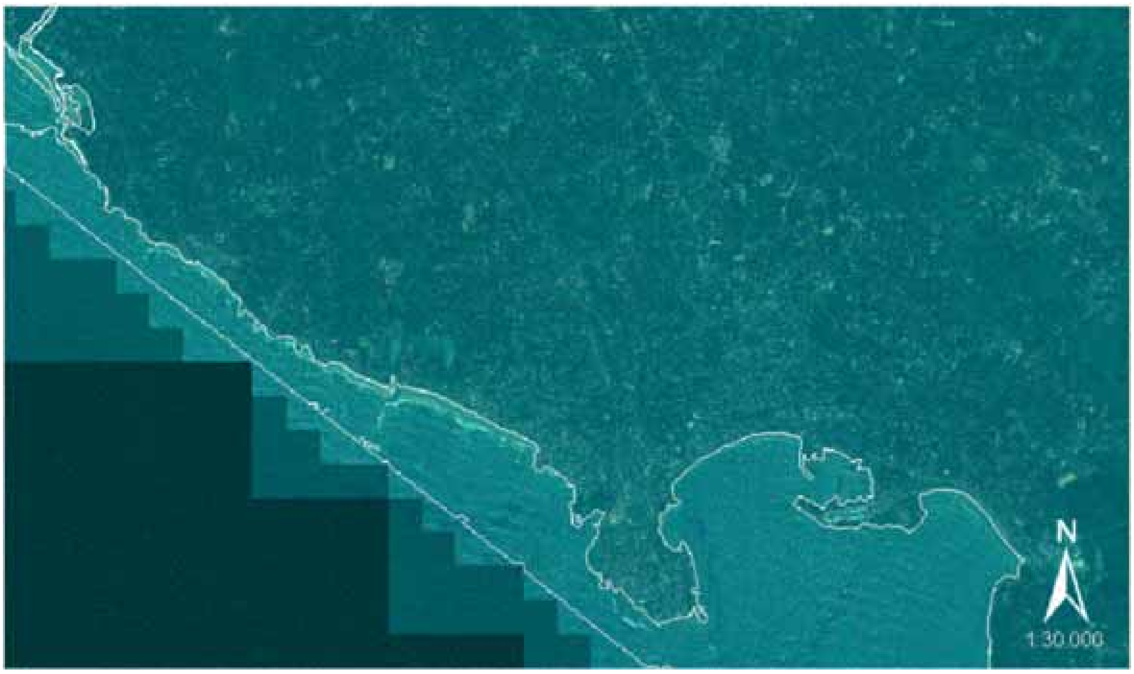
3.3 Exposure – Possible Risk Area Assessment

Addressing vulnerabilities implies an identification process – in other words, vulnerability to what? In this study the focus was on tsunami hazards and the location of objects with respect to the sea; thus the distance to the sea as well as the height of the terrain compared to the sea level were used as first parameters to estimate the vulnerability of the built environment to tsunamis. In this context different methods to derive and establish the exposure areas were tested and compared with each other. These involved a simple distance to the coastline (established from maps and satellite imagery) and a more detailed topographic analysis using digital elevation models to establish a certain elevation contour line as an indicator for the exposure zone.

a) Distance to the sea

To derive the high-risk area with respect to the tsunami hazard, the distance to the shore line is a very intuitive and straightforward parameter. The 100m buffer zone established for the south-west of Sri Lanka by the government was used as a first classification and testing element. However, most maps are outdated, so the development and definition of an accurate shore line was needed first. A basic automated coastline detection algorithm was used on satellite imagery in order to support the identification of high-risk areas.

Figure 5: Automatically derived shore line based on multispectral properties

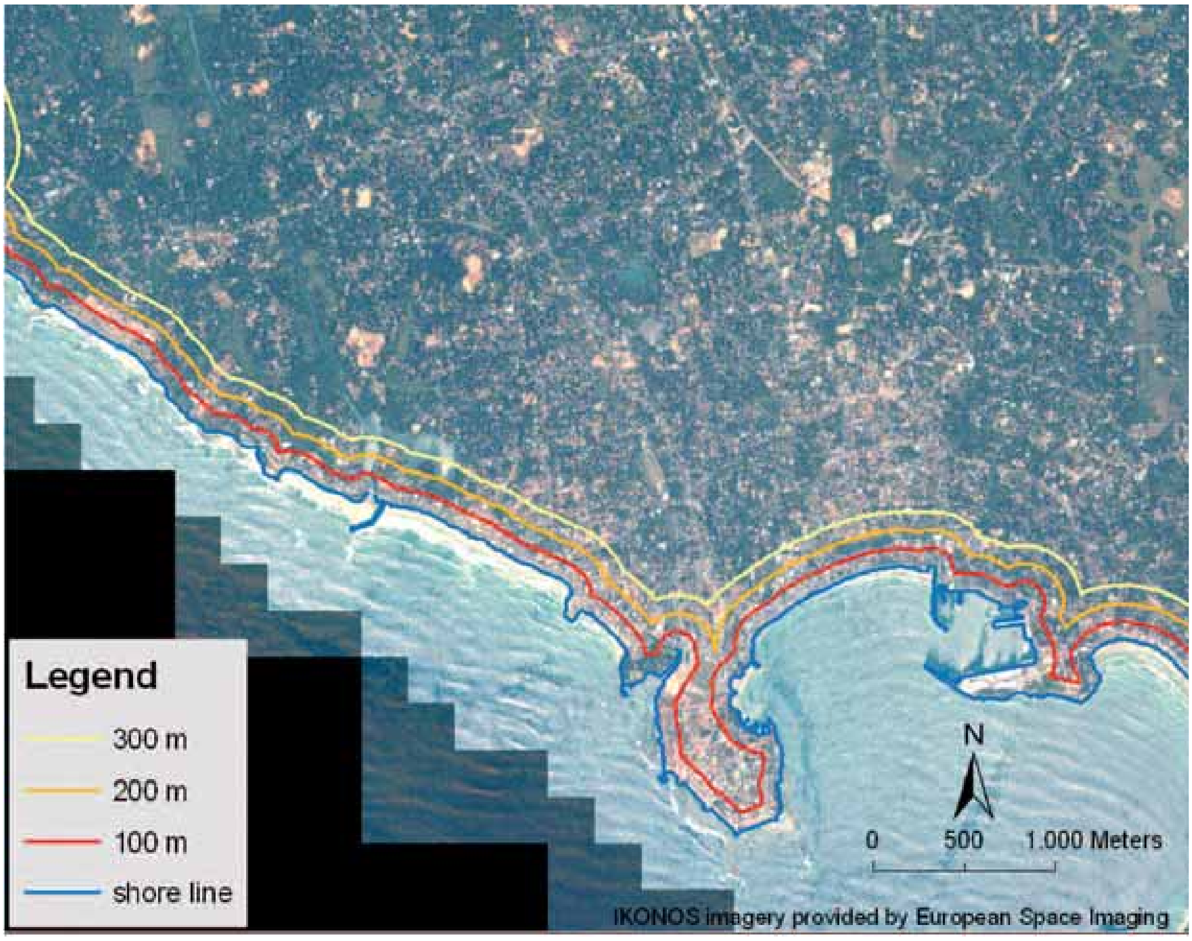


Source: M. Naßl and S. Voigt

These results were compared with other shore lines derived from maps and digital elevation models. Figure 5 shows the result of an automatic detection of the coastline based on the analysis of the multispectral properties. The automatic method was time-saving, but work is needed to pre-process the data since it has to be transformed into a common coordinate system. Also, visual interpretation can be used to establish the shore line in a satellite imager, but this may be time-consuming and accuracy depends strongly on the skills and experience of the interpreter.

Comparing the results of the automatic and visual interpretation methods for detecting the coastline shows that the automatic methods can be slightly less accurate in some places when compared with the results of an experienced interpreter. However, the results are sufficiently accurate to establish a risk area based on buffer zones off the coastline. Once a sufficiently defined coastline is established, GIS-based operations can be used to derive, for example, the 100m zone. The blue line in Figure 6 shows the coastline derived from satellite imagery, while the red line illustrates the '100m buffer zone in Galle' defined by the government. The orange and yellow lines indicate the 200m and 300m zones respectively.

Figure 6: 100m, 200m and 300m lines from the shore in the city of Galle



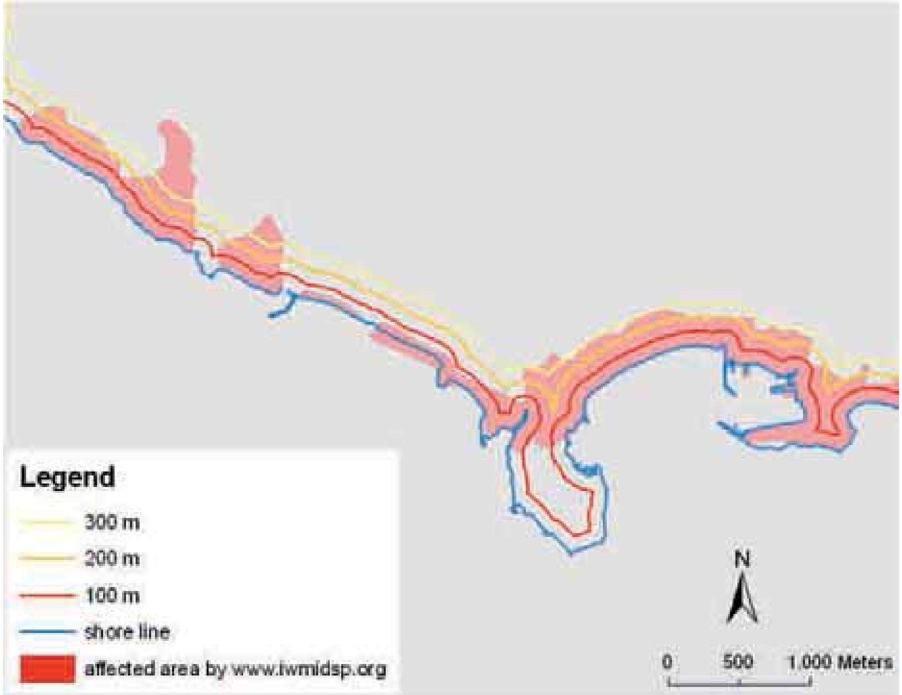
Source: M. Naßl and S. Voigt

b) Elevation

The dynamics of the tsunami of December 2004 have shown that even more significant than the distance to the sea is the terrain height above sea level. The Digital Elevation Model (DEM) (see Figure 8) is the result of the manual digitisation of the level curves of a large-scale map of the city of Galle dating from the 1970s. This is apparently the most up-to-date map of Galle. From the level curves, the DEM was derived and interpolated automatically. Using DEMs, estimations of the possibly affected area can even be refined, as the dynamic water inundation will follow the contour lines closely. That means that the 100 meter buffer zone is not sufficient, as in some areas the tsunami wave went far further inland, particularly in very flat areas and in areas in where a river allowed the wave to travel several hundred meters inland.

Comparing these different risk or exposure zones (100m vs. DEM-derived) it is possible to analyse their validity for a given tsunami threat and for a given settlement structure such as in Galle. In order to prove the concept of these zonations, the actual damage area was derived from satellite analysis and cross-compared with the different zones. It shows that the affected (heavily damaged) area fits quite well with the topographic elevation line of about a 3m level curve blended with the 100m and 200m shore line buffers (see Figures 7 and 8).

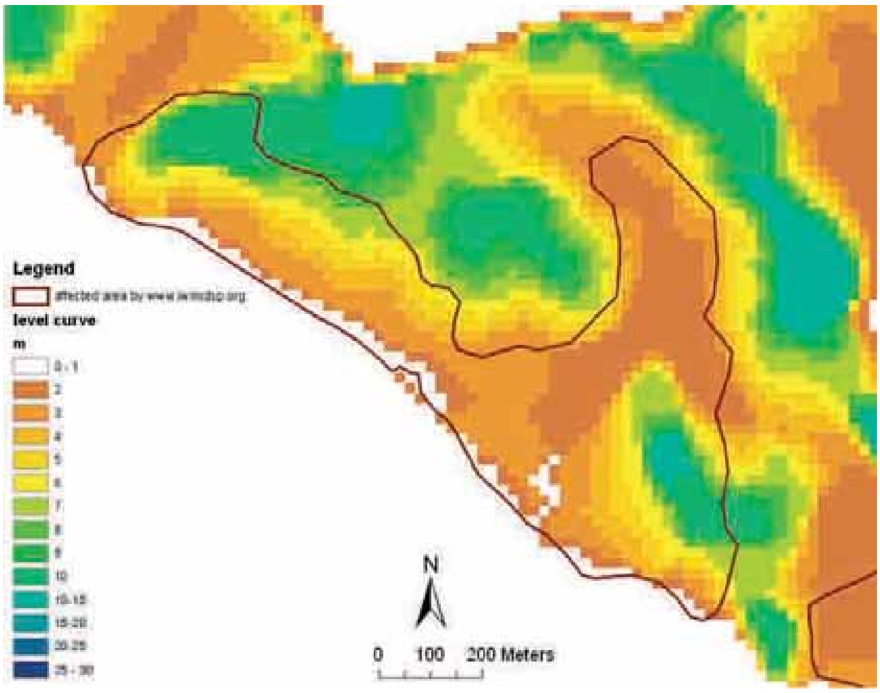
Figure 7: Shore line and 100m, 200m and 300m lines blended with tsunami-affected area: Galle



Source: M. Naßl and S. Voigt

For Galle the comparison showed that the 100m line – and in several areas also the 200m line – was underestimating the actual inundation area. However, the 3m elevation contour line was sometimes, or in some areas, not an appropriate tool to define the highly affected area. Overall, for Galle, the 100m line and the 3m level curve can be used as a first estimation to define the zone most at risk. But this can not be defined as a general rule since it only reflects the specific conditions for this particular event in Galle.

Figure 8: Tsunami-affected area blended with Digital Elevation Model: Galle



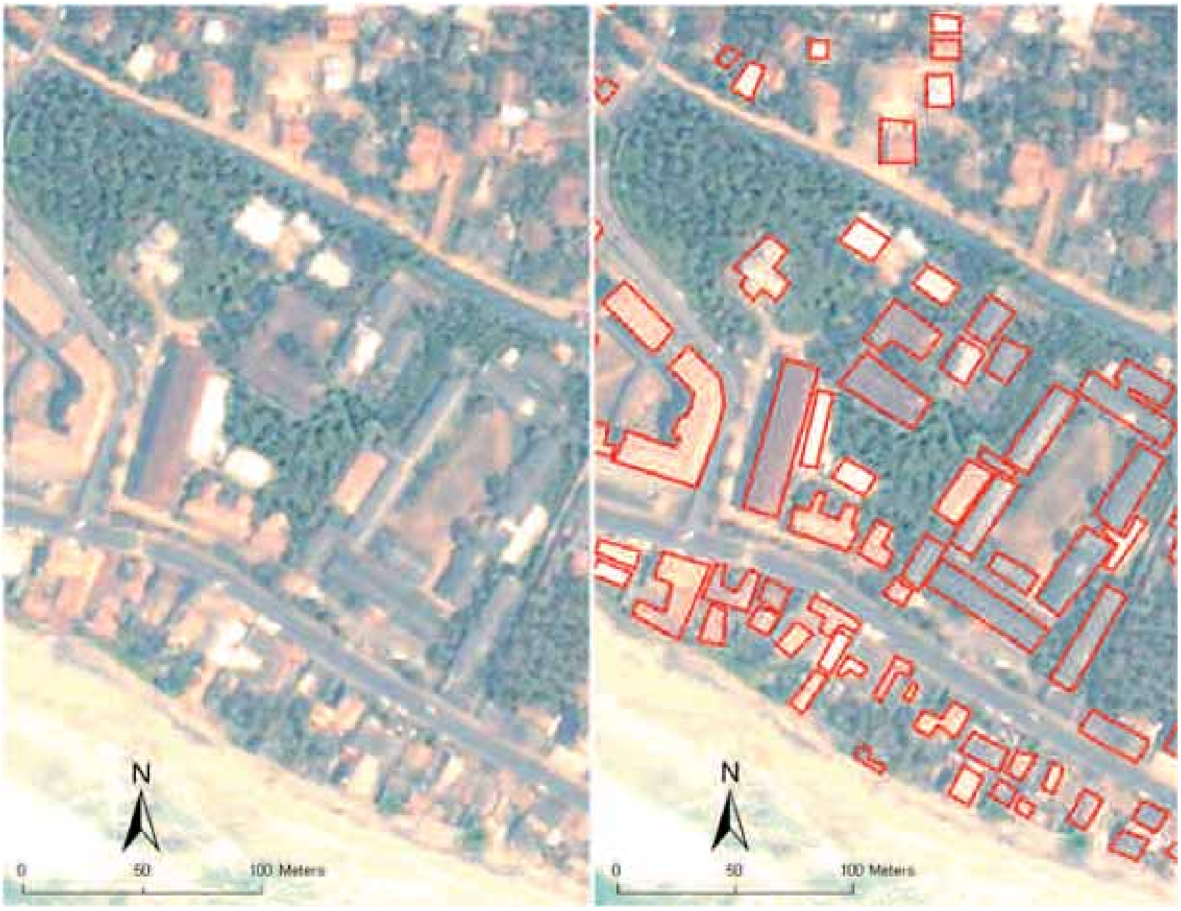
Source: M. Naßl and S. Voigt

3.4 Assessment of Settlement Structures

The settlement structures are the key to estimating the vulnerability of the built environment. For example, it was assumed that the structure and quality of the built environment could also help to estimate the conditions of people living in these areas.

Although a visual interpretation and manual digitisation of individual houses in the study areas was very time-consuming, it was carried out nevertheless for selected areas in the affected damage zones. This was done mainly to provide reference information and to evaluate the results of automatic analysis methods. Individual examples may show the difficulties that can arise from both manual digitisation and automatic analysis. Figure 9 shows a part of Galle in the 'damaged zone', indicating manually digitised houses as they could be identified on the imagery acquired prior to the tsunami event.

Figure 9: Creation of settlement layer in a GIS with visual interpretation methods: Galle



Source: M. Naßl and S. Voigt, based on IKONOS satellite image

Tests have shown that using an automated detection method of single houses is possible. However, it may also result in misinterpretations due to limitations in the ability to distinguish individual houses and other image elements.

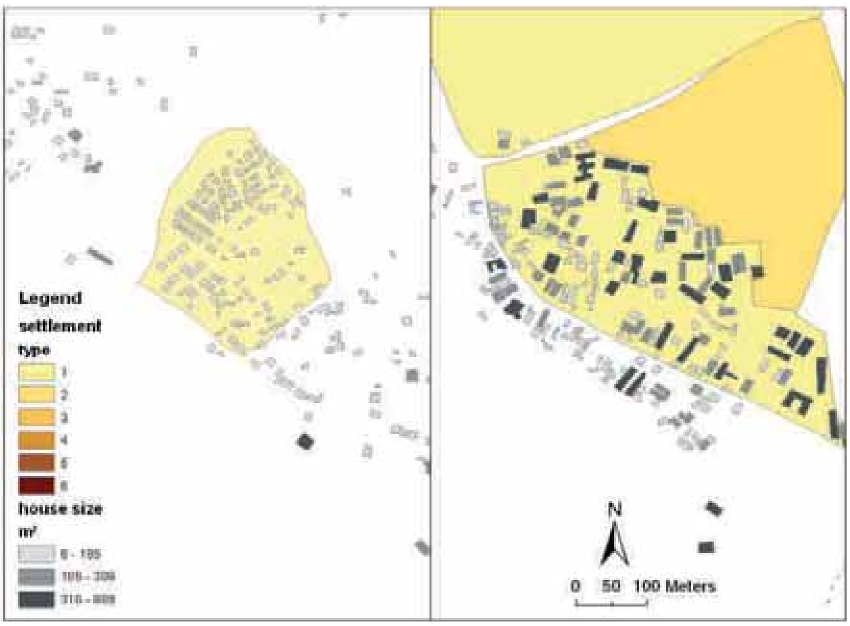
The quality of the houses and density of certain building parameters served as indicators to assess the settlement structure and its quality. For example, a hypothesis was formulated that large single housing units indicate a wealthier urban area than highly dense small housing units. The analysis focused, therefore, on the individual building and its roof. The image on the right in Figure 9 shows that roofs of the houses are visible, and that the colour and size of a roof can be derived. However, even then, it is still difficult to derive quality information on the house simply from status and size of the roof. The following example underlines these difficulties.

Figure 10: Selected settlement areas suggesting different structure types in density and quality: Galle

Source: M. Naßl and S. Voigt, based on IKONOS image and ground survey by University of Colombo

When comparing the results of the reference data survey characterising six different quarters with respect to their different settlement types (see Figure 10), with a layer of individual houses derived from the satellite imagery one can see that the pure distribution of houses does not necessarily indicate characteristics of the settlement type directly. Figure 11 compares the class 'high dense settlement with high-quality construction' with a set of the manually analysed houses in respect of size (high grey value resembles large houses and therefore high construction quality, and vice versa). Apparently, the typical feature of a high number of large houses is missing completely in the example on the left. Using automatic detection, the two areas would not be allocated to the same class.

Figure 11: Highly dense areas with high-quality structures compared with single housing units classified by size: Galle

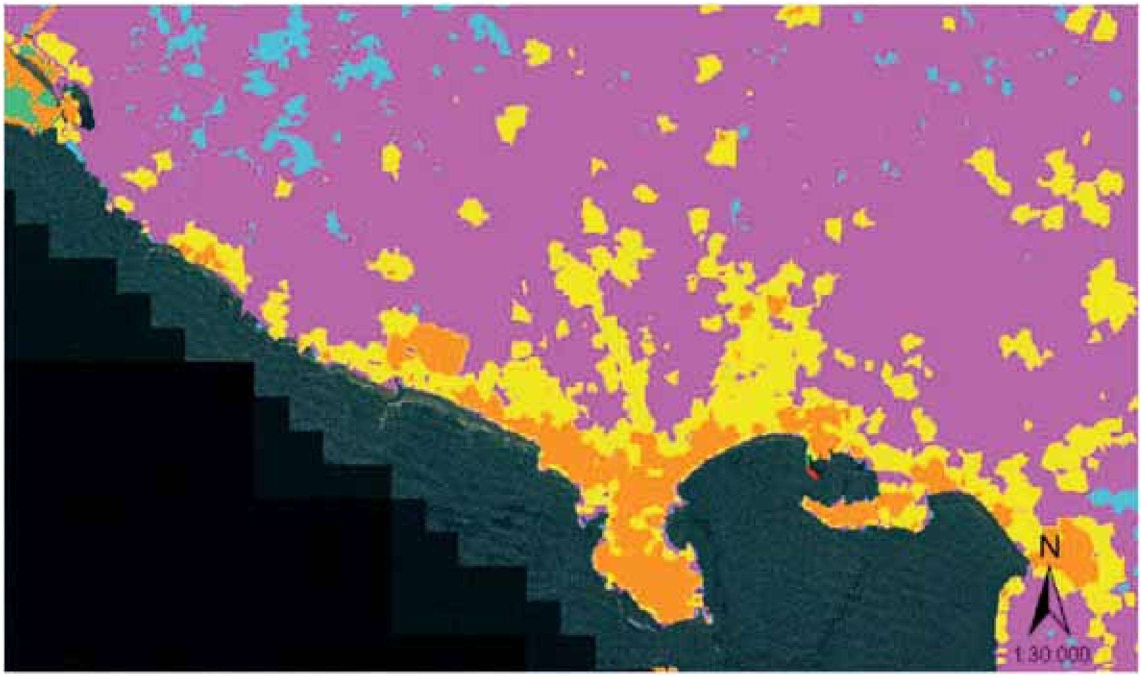


Source: M. Naßl and S. Voigt

Figure 11 shows the difficulty of deriving features such as the construction quality of houses from proxy indicators like roof size. The results of these experiments proved, that this method is hard to apply for the whole city, especially if only the basic feature of housing size is used. This means that for a city such as Galle, which is characterised by its mixed urban structures, it is very difficult to use automated methodologies and classification tools to derive and define different settlement structure types and housing qualities.

As for deriving settlement density, an automated method could be applied quite successfully. With the help of near infrared and visible satellite image channels, the Normalised Difference Vegetation Index (NDVI) was calculated for the area of the satellite imagery. During several processing steps the imagery was segmented into homogenous areas of vegetation and non-vegetation density, spastics were derived for these areas and finally aggregated into classes where low vegetation density values indicated a high settlement density or, more generally, constructed areas including street or harbour areas.

Figure 12: Density of the built environment derived by automated methods: Galle



Source: M. Naßl and S. Voigt

Through an unsupervised classification the result contains around five classes of different density types. By visual analysis the density can also be measured, but with a longer investigation time. In this case every house would have to be digitised manually and reference areas would have to be defined to calculate the density for each reference area. Figure 12 shows the density of the built environment; orange-coloured areas indicate highly dense areas, while yellow and pink indicate lower-density classes. Interestingly, highly dense areas are located close to the sea.

3.5 Data and Obstacles

In general, remote sensing and reference data is key in such analysis. These days satellite imagery has a typical ground resolution of around 1m at the most. For some parts of the analysis even higher resolution imagery could be used. However, a higher spatial resolution results in increased data volumes and is often more difficult for automated classification algorithms. Also, imaging conditions such as sun elevation, angle of data take and atmospheric distortions may influence the quality of the data.

3.6 Prelimenary Conclusions

Satellite remote sensing can be used successfully to derive indicators of physical vulnerability, by analysing the structural, spatial and contextual properties of urban objects. However, any further processing to derive economic and social vulnerabilities relies on ground-based information taken from census data, statistics or other sources, and is mainly derived in GIS analysis building on spatially distributed data. When purchasing satellite imagery it is advisable to ensure the best level of pre-processing and rectification, either 'off the shelf' or through in-house analysis and processing capacities. Only then an optimum result can be achieved in the following vulnerability indicator mapping.

4 Critical Infrastructure and Sector Vulnerability

by J. Birkmann, M. D. A Nandana

4.1 Introduction – Mapping Critical Infrastructure and its Vulnerability

Analysis of the vulnerability of critical infrastructures and sectors (schools, hospitals, banks) focused in its first phase (rapid assessment) on the degree of spatial exposure of the different units in Galle municipality, even though we acknowledge that vulnerability encompasses exposure, susceptibility and coping capacities (see Figure 1). However, the assessment of susceptibility of critical infrastructure would require in-depth analysis of single buildings and lifelines, which implies a time-consuming study that was not feasible within the scope of this study.

4.2 Methodology

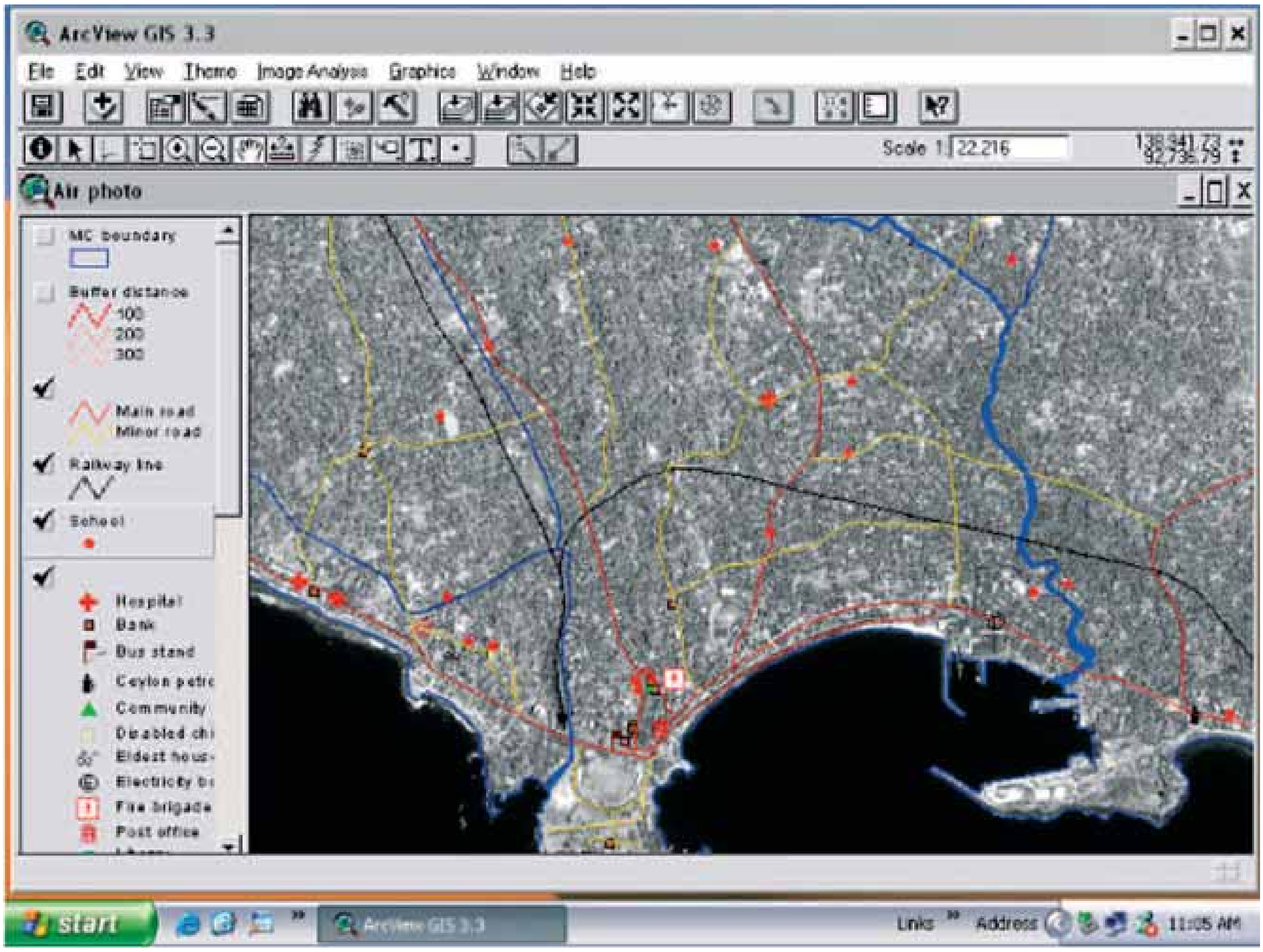
As a first lens, the degree of exposure was used as an indicator for vulnerability. As discussed within the framework of the remote sensing analysis of Galle, one could develop different zonings to classify the degree of exposure of different infrastructures at risk. In the vulnerability assessment in this study it was decided to use the Government's definition of the 100m zone (buffer zone) in the south-west of Sri Lanka to measure and classify the degree of exposure of different critical infrastructures and sectors. In this context the GIS analysis and ground survey (see Figure 13) aimed to identify the degree of exposure of different elements and units, such as schools and banks, assessing the number of schools, for example, in the 100m zone (from the sea) compared with the total number of schools in Galle municipality.

This means that if a high concentration of facilities of a specific critical infrastructure – such as hospitals – is located within the 100m zone, this infrastructure or sector is more vulnerable to coastal hazards and tsunamis than those whose major facilities are located further inland. In order to capture information with regard to the hinterland, the research takes into account the 200m and 300m zones and farther from the sea.

4.3 Results for the City of Galle

Our analysis revealed that 50 percent of the hospitals, approximately 20 percent of the banks and 13 percent of the schools (four schools) are located in the 'high-risk zone' (100m) in Galle municipality. Therefore, the health infrastructures, banking and schooling sectors are particularly vulnerable to tsunamis due to their high degree of exposure.

Figure 13: Spatial exposure of different critical infrastructures: Galle



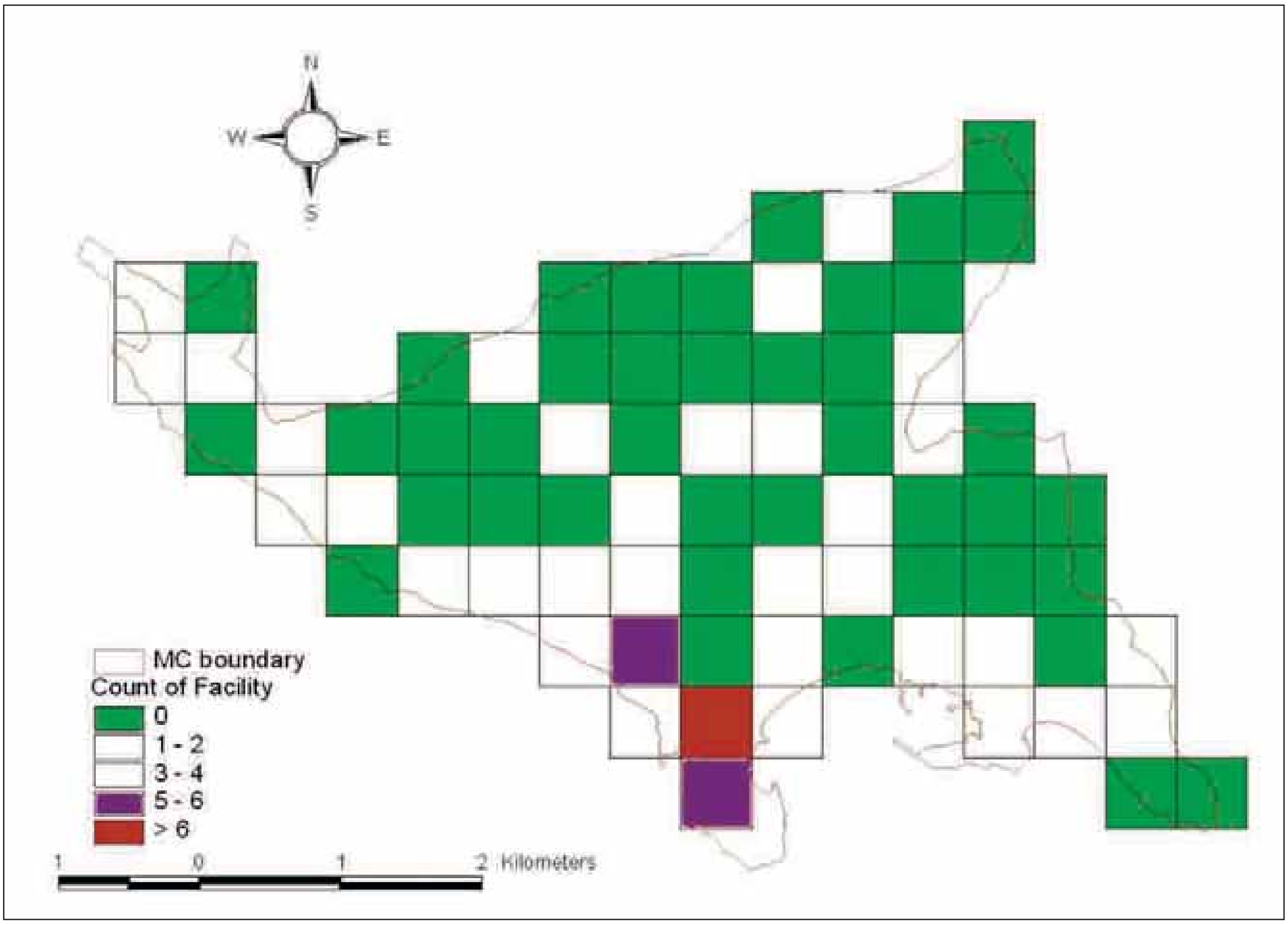
Source: J. Birkmann, M. D. A Nandana, based on satellite photo IKONOS

The distance from the sea is only one indicator which allows a first estimation of vulnerability with regard to exposure. However, these indication tools are only meant to give a general overview. A precise picture would imply also taking into account the impact of the built infrastructure, such as buildings, roads and canal systems, to calculate different inundation scenarios.

The spatial distribution of critical infrastructures in Galle was also mapped in grid cells using 500x500m cells. Figure 14 shows that most critical infrastructures in Galle are located in one or two grid cells only, meaning that facilities are highly spatially concentrated and also close to the sea.

While some infrastructures and services in well-constructed multi-storey buildings, such as the district office, faced only minor damages because they were strong, the bus stand within the same grid cell was highly impacted. As a consequence, people waiting there for the bus in the morning were killed, and most of the mobile infrastructure, such as the buses themselves, was totally destroyed.

Figure 14: Spatial distribution of critical infrastructures: Galle



Source: J. Birkmann, M. D. A Nandana

4.4 Remarks and Preliminary Conclusions

For a general and first estimation of the vulnerability of different critical infrastructures/ sectors, the analysis of the amount of exposed elements in the 100m zone compared with those outside of a specific critical infrastructure/ sector seems adequate, since major damage was observed in the 100m zone compared to the 200m and 300m zones. For example, it became evident in the tsunami that the proportion of damaged housing units in the 100m zone was around 60 percent compared with only 3.3 percent in the 300m to 400m zones (see Chapter 9). This means that the spatial distribution of – and the likelihood of serious damage to – critical infrastructures is an important aspect of vulnerability. Moreover, the rapid assessment used within this short study did not include all the critical infrastructures one would wish to include, such as the radio station. Additional criteria, such as the structure and height of the building or the existence of preparedness measures – for example, emergency management plans for schools – should be added to an in-depth assessment of the vulnerability of critical infrastructure.

Future reconstruction and early warning have to define priority areas: whom and what to target first. If, in the case of Galle, major critical infrastructures are concentrated in one area close to the sea preparedness measures should be implemented before disasters occur. The methodologies shown can help to identify these critical areas. The example of the bus stand shows that if it was in a different location and early warning had been effective, people and mobile infrastructure presumably could have been protected – or at least their vulnerability reduced.

5 Vulnerability Assessment of Social Groups

by J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

5.1 Introduction

The vulnerability assessment of social groups was primarily applied and conducted in Galle municipal area using questionnaires, post-tsunami census data, in-depth interviews and focus group discussions (see Table 1). An additional questionnaire-based assessment was also carried out in Batticaloa; these results are presented in Chapter 6 as a comparison with the findings in Galle. Vulnerability assessment was measured using various methodologies and techniques. Primary and secondary data was collected in order to develop and derive a broader picture of the most important characteristics of vulnerable people and groups. The secondary data is shown in Chapter 9. Some of these techniques were used to investigate information throughout the municipal areas while others were used in sample locations and selected areas for more in-depth analysis.

Table 1: Research techniques used to measure vulnerability of social groups

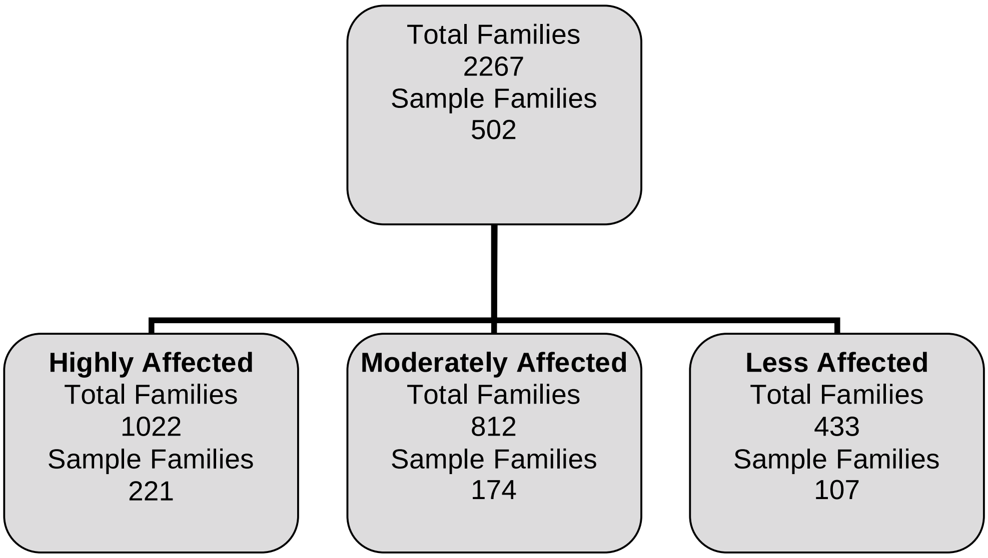
Data	Quantitative	Qualitative	Focus
Primary	Household survey questionnaires	In-depth interviews with key informants Focus group discussions Observations	Sample location and selected areas
Secondary	Post-tsunami census	Literature Reports	Municipal area

Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

5.2 Methodological Aspects of the Household Survey

The household survey using structured questionnaires was carried out in Galle, in six sample communities. Since the intensity of the hazard also influenced the revealed vulnerability of humans and physical structures it was important to capture the various vulnerabilities related to different impact intensities. This means that the sampling framework took into account the intensity of damage caused by the tsunami. Thus the questionnaire-based household survey needed to cover communities and households in highly affected, moderately and less affected areas. Two communities were selected from each category, based on the post-tsunami census data, and the total sample consisted of six communities. The required sample size for each community was calculated following the sampling method of probability to proportion to size. Figure 15, shows the sample families of each selected community in the affected areas. A representative sample of the families within these six GN divisions was selected, encompassing 502 families. For this purpose population information in relation to the six selected GN Divisions was used, based on the post-tsunami census, to identify the specific sampling frame in order to select the sample population for the study. A total of 502 interviews – comprising 73 questions with around 610 possible criteria – were conducted by the enumerators in face-to-face interaction with respondents during a four-week period. Thereafter the data was entered and analysed using SPSS.

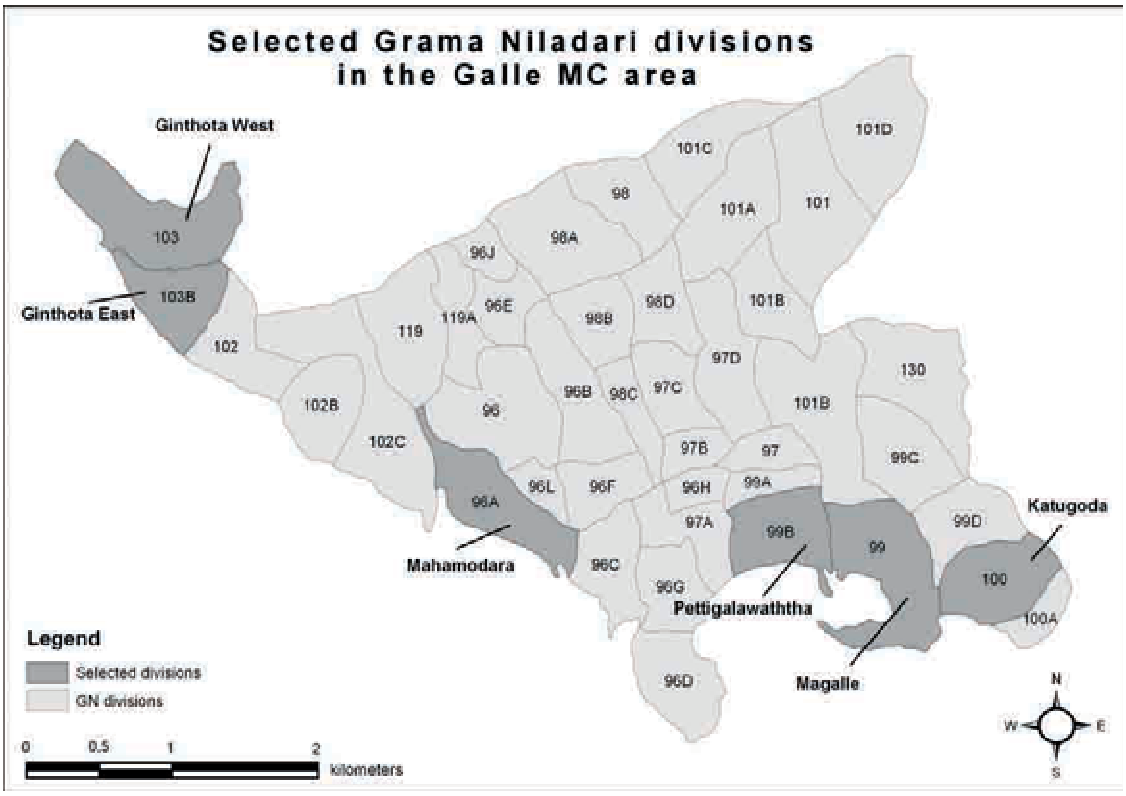
Figure 15: Structure of the sample in selected GN Divisions in Galle



Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

Questionnaire interviews were conducted employing both male and female graduate research assistants. Focus group discussions were also conducted to find out the views of different groups of affected people in the sample locations, and to generate more precise information for interpretation and context assessment (see Chapter 7). The questionnaire-based identification of vulnerability and most vulnerable groups was used in six GN divisions shown in Figure 16.

Figure 16: Overview of selected sites in Galle for questionnaire-based research



Source: Nandana and J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

All the GN divisions are located directly by the sea and represent different damage categories, i.e. heavy, medium and low damage. This information was derived from specific tsunami impact information (revised RF1 sheets) collected by the census department in all tsunami-hit districts after the tsunami. This helped to update the 2001 census data in all tsunami-affected districts.

5.3 Structure and Content of the Questionnaire based Household Survey

The structure and content of the questionnaire take into account the BBC-framework (see Figure 1) and also aspects of the sustainable livelihood framework (DFID 1999). Accordingly, it captures vulnerability with regard to susceptibility and exposure on the one hand, and in terms of coping capacities on the other. It also addresses the social, economic and environmental dimensions of vulnerability. In addition, it focuses on intervention tools in order to derive information on potential, or already implemented, policy interventions to reduce vulnerability. This means that the vulnerability of families was explored through the following elements:

- Exposure: amount of infrastructures located in the high-risk zone;
- Susceptibility: quality of housing material, gender, age, landownership;
- Coping capacities: social networks, income in relation to damage, savings; and
- Intervention tools: access to information (radio, etc), knowledge, '100m buffer zone'.

The questionnaire-based research covered such aspects as:

Vulnerability

susceptibility and degree of exposure

1) Impact of Tsunami on household members and their assets;
2) Structure of household;
3) Housing conditions and impact of tsunami;
4) Direct loss of possessions; and
5) Activity and occupation of household members.

coping capacities

6) Social networks;
7) Knowledge of coastal hazards and tsunami;
8) Financial support from formal and informal organisations; and
9) Access to information, e.g. radio.

intervention tools

10) Relocation of housing and infrastructure to inland;
11) Early-warning system; and
12) 100m 'buffer zone' (implemented by the government).

Source: Birkmann et. al 2006

5.4 Selected Results for the City of Galle

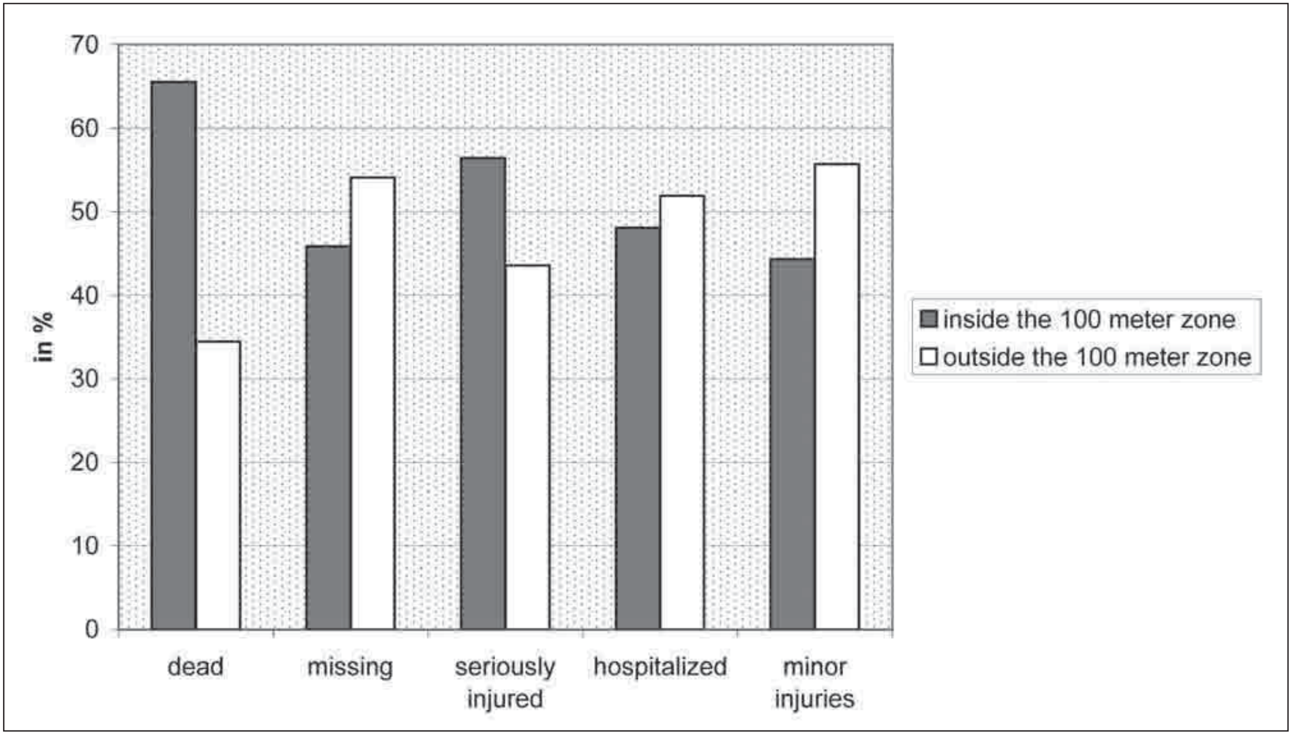
5.4.1 Exposure

Based on the damage faced by individual households during the tsunami, the questionnaire data allowed for the comparison of damage patterns within the first 100m from the sea and outside of it, primarily within the zone of 100m to 300m from the sea. Because the sample outside the 100m zone was larger than the sample inside, a statistically reliable and adequate sample of households outside the 100m zone was generated using a random choice analysis 99 times, and also applying the Friedman test (Hartung 2002: 622).

The household survey data shows that people within the 100m zone from the sea were more likely to die than those in the 200m (100m-200m) and 300m (200m-300m) zones, although the inundation area often spanned beyond the 200m and 300m zones inland. The indicator 'dead household members' shows that the likelihood of being killed by the tsunami in the 100m zone was twice as high as in the 200m and 300m zones from the sea (see Figure 17, below). While the proportion of deaths outside the first 100m accounts for 34 percent, the proportion of deaths in the 100m zone accounts for 66 percent.

In contrast, the amount of people suffering minor injuries was higher outside the first 100m than inside. This underlines that although the wave went further inland than 100m, the pattern of death and injury in Galle shows significant differences between the first 100m and the areas of the 100m-300m zones.

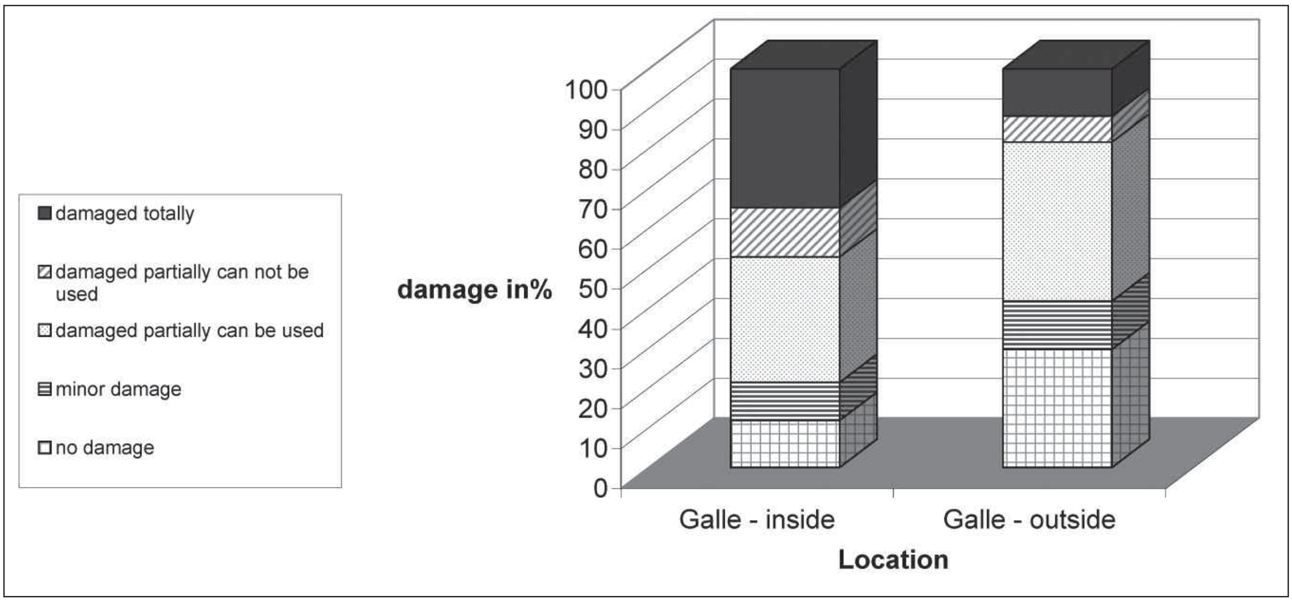
Figure 17: Human impact inside and outside 100m zone in selected GN Divisions: Galle



Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

In addition, with regard to physical damage major differences were revealed between the 100m zone and the area outside it (100m-300m from the sea). While 40 percent of the houses inside the 100m zone were totally destroyed, the same category outside accounts for less than 20 percent (see Figure 18).

Figure 18: Housing damage inside and outside the 100m zone: Galle



Source: Birkmann

Overall, the physical damage pattern in Galle – based on the household survey – also underlines the significant differences between the first 100m from the sea and the area beyond. The total amount of uninhabitable buildings (those that can not be used anymore) is 60 percent inside the 100m, while this category accounts for only 25 percent outside the zone. In other words, in Galle the differentiation between the 100m zone and the 200m and 300m zones shows major differences with regard to human and physical impact.

The housing type also made a difference. The analysis of damage according to the housing type showed that the proportion of single houses 'totally damaged' and 'partially damaged but unusable' was about 50 percent, whereas the multi-storey buildings captured in this zone for the same categories accounted for about 17 percent. Interestingly, the amount of 'totally damaged' single houses and those that were 'partially damaged but unusable' outside the 100m zone was about 20 percent, while the same categories for the multi-storey buildings accounted for 11 percent. This means that both housing types suffered greater damage inside the 100m zone compared with outside. Therefore the distance to the sea is important. On the other hand, a major difference can be seen in the lesser damage of multi-storey buildings within the 100m zone compared with single housing units. We assume that, in general, the construction of multi-storey houses close to the sea was more robust and of higher quality than the average single housing unit.

5.4.2 Susceptibility

In order to estimate the current susceptibility and coping capacities of different social groups and households to coastal hazards and, in particular, tsunamis, we tested different indicators in order to explain the revealed vulnerability, and also to estimate the present vulnerability and coping capacities. We selected and tested the following indicators, among others, in terms of their relevance to visualise different revealed vulnerabilities:

- *Amount of young and elderly people in the total population;*
- *Gender;*
- *Income;*
- *Employment;*
- *Land ownership;*

- *Social networks and membership of organisations;*
- *Loans and savings; and*
- *Potential recovery time (index).*

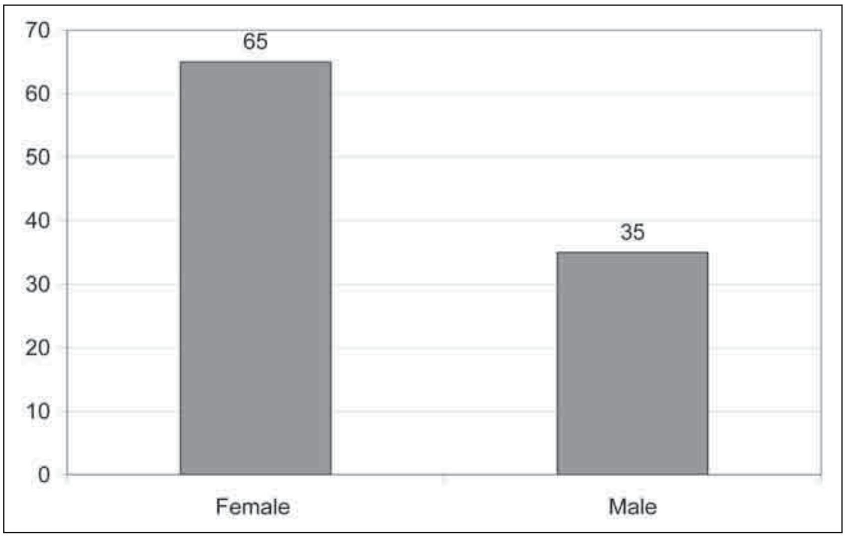
Young and elderly people/demographic vulnerability

Statistical analysis of the questionnaire data on demographic characteristics of dead and missing people showed that the youngest age group, 0-9 years (25 percent), and the age groups over 40 years were highly vulnerable to the tsunami (44 percent). With regard to the absolute number of dead and missing the youngest age group shows the most fatalities.

Gender

Gender also played an important role with regard to the dead and missing. The questionnaire results showed that nearly twice as many females (65 percent) as males (35 percent) were dead or missing (see Figure 19).

Figure 19: Dead and missing according to gender in Galle



Source: Birkmann

These results correspond with the findings of other surveys on tsunami impacts and risk factors for mortality and injury. For example, a study by the Centre for Research on the Epidemiology of Disasters (CRED) in affected rural areas in Tamil Nadu in India shows a clear difference in the mortality pattern between male and female. Female deaths accounted for 8.6 percent, while the proportion of males killed by the event was around 6 percent. Therefore, a higher mortality rate of females than males was observed in a household survey in India (Guha-Sapir et al. 2006). Another study, conducted in Banda Ache by Oxfam, also identified the higher risk of women being killed by the tsunami (Oxfam 2005).

One can conclude with regard to demographic and gender that in terms of revealed vulnerability, small children, elderly people and women were the most vulnerable groups.

Income and employment

Although indicators such as income decline and unemployment represent impacts, they also underline the different vulnerabilities of different occupational groups in different areas as well as varying abilities to cope with, and recover from, secondary tsunami impacts. The analysis of income-earning activities showed that households earning 5,000 rupees or less per month before the tsunami lost considerable income afterwards, and were more likely to lose their job than those households with a relatively high income. Most of them were engaged in daily paid labour as mobile fish sellers and fishermen, and some were engaged in other types of small-scale selfemployment. In contrast, the households that earned a monthly income of 21,000 rupees or more (18.4 percent) did not suffer from such negative impacts with regard to income. These households often had more than one income earner with permanent employment in either the government or private sector. Also, small-scale businessmen, fishermen and selfemployed people who earned a monthly income of 5,001 to 20,001 rupees before the tsunami were facing an income decline or had lost their job. However, they were better off than those households in the lowest income category, who experienced another decline in their already low income.

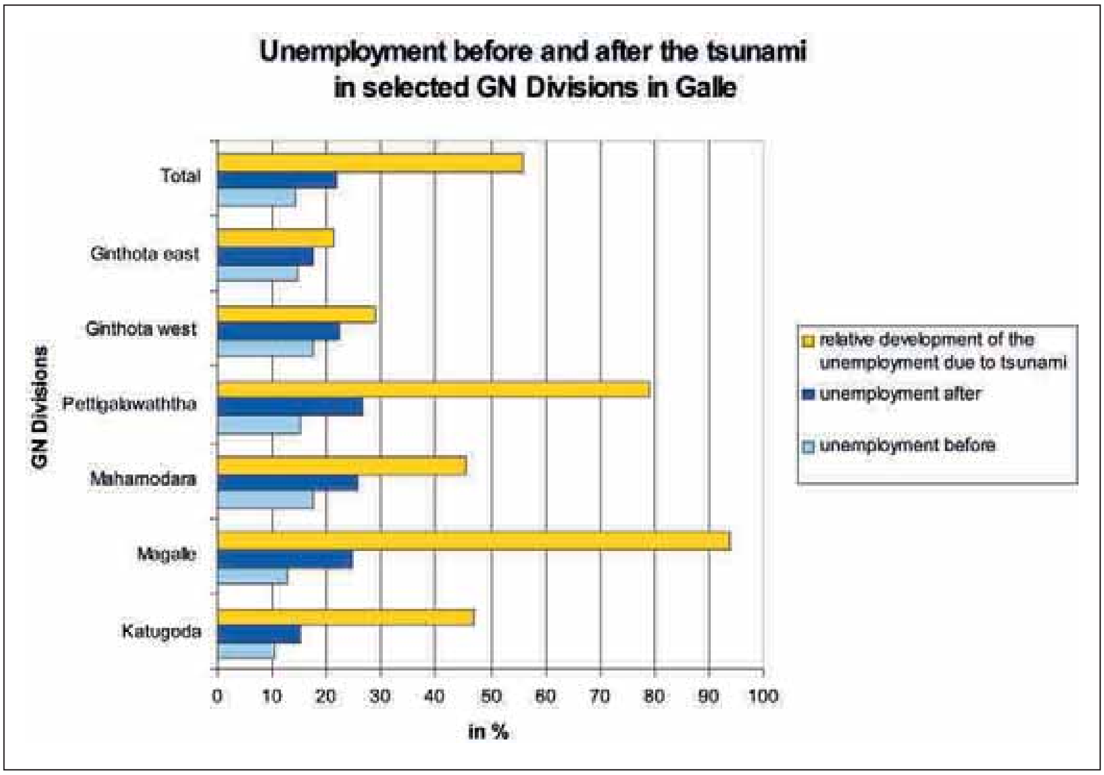
5.4.3 Coping and Recovery

Although coping is often associated with processes in the event (e.g. drought – eating fewer meals), this study relates also to coping capacities after the tsunami, particularly when issues such as unemployment or lack of access to clean water imply that households have to cope with these secondary impacts. Therefore, coping and recovery are examined in this study in terms of their impact on livelihoods, with regard, for example, to the growth in unemployment after the tsunami, or in terms of the time a household might need to replace its actual damages.

Changes in unemployment after the Tsunami

In order to measure coping and recovery difficulties, changes in activities and unemployment were examined. Household members were classified according to the following activities, based on over 2,500 valid answers: 'student', 'household work', 'unemployed', 'employed' and 'unable to work'. In the categories 'student', 'household work' and 'unable to work' no major changes were observed, but the categories 'unemployed' and 'employed' indicated significant changes. In all six selected GN divisions in Galle unemployment increased as a result of the tsunami. However, analysis reveals significant differences with regard to the increase in unemployment between the GN divisions.

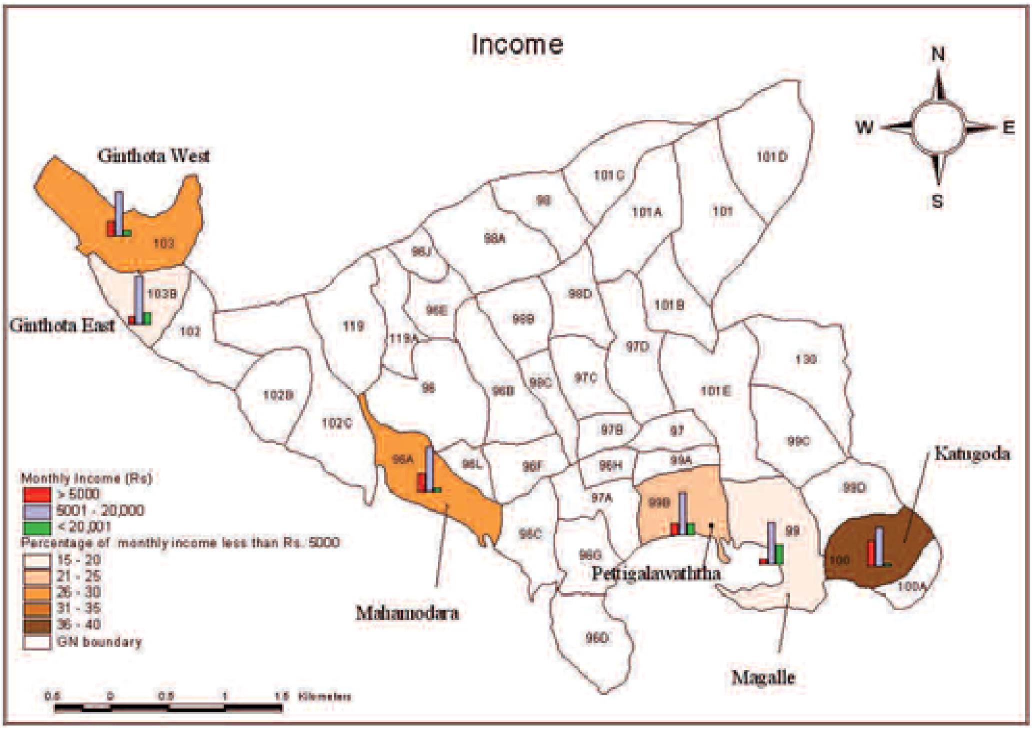
Figure 20: Development of unemployment before and after the tsunami: Galle



Source: Birkmann

Figure 20, above, shows that in Magalle and Pettigalawaththa unemployment increased dramatically: the relative development shows a dramatic increase – more than 90 percent. In contrast, Ginthota East and Ginthota West show only a moderate increase in relative unemployment. Katugoda and Mahamodara also faced a high increase in the unemployment rate, by more than 40 percent. The relatively low increase in Katugoda is surprising; this might be influenced by the fact that in Katugoda more than 25 percent of respondents were engaged in household work, which can generally be continued even with limited resources.

Figure 21: Income levels of households in the selected GN divisions: Galle



Source: Birkmann

In Katugoda the economic and financial status and capacity of households to replace losses was generally lower than in Magalle and Ginthota East. Although Katugoda did not show a dramatic increase in unemployment in contrast to Magalle and Pettigalawaththa, many households already had a very low income, so they were likely to face unusual difficulties in recovering from the negative impact of coastal hazards. It is an important task for the future to monitor whether the increase in unemployment in, for example, Magalle will hold for longer and thereby influence the socio-economic status of households. Income data for households after the tsunami was not reliable enough to derive evidence with regard to this impact, therefore we had to use income data before the tsunami as a calculation basis to identify income-related vulnerable areas.

Potential recovery time of households

The impacts and revealed vulnerabilities of different social groups, such as women and the elderly, are one aspect of this study. However, the BBC-framework (see Figure 1) underlines that both susceptibility and coping capacities should be taken into account in a broader vulnerability assessment approach. Wisner, for example, points out that the unusual difficulty in recovering from the negative impacts of a hazardous event is an aspect of vulnerability (Wisner 2002). In this context we developed a methodology to measure the potential time of a household to recover from the impact of a given disaster. This 'recovery index' is based on the idea of a human security index proposed by Plate (Plate 2006). However, we developed and calculated a modified and simpler version, according to the data we could capture within the framework of the household questionnaire.

The intention of the modified index was to measure the potential recovery time of households after the tsunami, by analysing the income patterns of the individual household compared with the losses and damages it faced. Due to the fact that households faced various losses of possessions, but little data with regard to the replacement costs was available, we decided to base the measurement of the potential recovery time on selected items. So we focused on the actual housing damage the households faced and the general reconstruction costs according to selected damage categories (see Table 2). Based on this data we calculated the specific time a household would need to replace damages caused by the tsunami. First we calculated the free available income of the household by calculating the sum of the household income before the tsunami minus the minimum subsistence level (minimum subsistence level for Sri Lanka is calculated at 1,428 rupees per month). Thereafter we estimated the damage and reconstruction costs of the specific household according to four damage categories captured in the questionnaire: 'damaged totally', 'damaged partially cannot be used', 'damaged partially can be used' and 'minor damages'.

Table 2: Translation of damage categories into reconstruction costs

No.	Damage category of the house	Estimated reconstruction cost for the house
1	Damaged totally	250,000 rupees
2	Damaged partially cannot be used	200,000 rupees
3	Damaged partially can be used	100,000 rupees
4	Minor damages	20,000 rupees

Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

On this basis we calculated the time, in months, that the specific household would need to replace its housing damage assuming that it would spend all of its free available income on this task – based on income data before the tsunami (income data after the tsunami was not reliable). Analysis showed that, already before the tsunami, 19 out of 500 households (3.8 percent) would not have been able to replace any loss, while since the tsunami 31 out of 500 households (6.2 percent) are currently unable to replace their losses using their own financial capacity. However, we had to use income before the tsunami for the calculation, since income data after the tsunami was not reliable.

Furthermore, from those households able to replace faced losses, due to an income above the minimum subsistence level, around 23 percent did not face any damage, and therefore needed no time to replace the losses; 31 percent of the households were able to recover or replace their housing damage within a year. In contrast, 29 percent of the households need more than two years to replace their faced housing damage, or are not able to recover at all (4 percent) (see Table 3).

Table 3: Potential time households need to replace housing damage: Galle

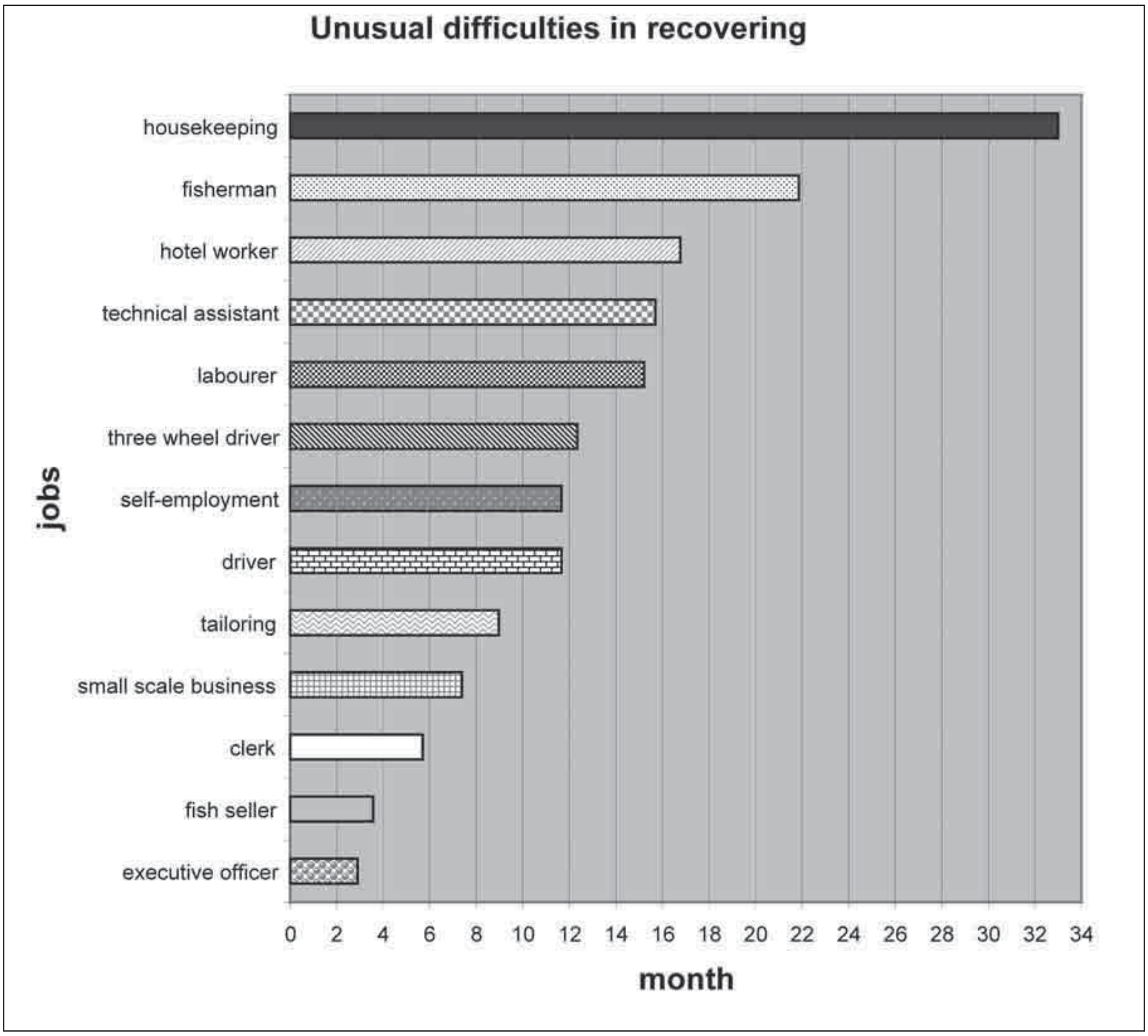
Potential time needed by households to recover from experienced housing losses	Absolute number of households	Relative number of households
No damage	116	23%
1 day to 12 months	153	31%
12 months and 1 day to 24 months	86	17%
25 months and more	126	25%
Not able to recover at all (household under poverty line)	19	4%
Total	500	100%

Source: Birkmann

One can conclude that around 30 percent of all households captured in the questionnaire in the six selected GN Divisions depended on external financial support to be able to rebuild their house or replace the faced damage to the house. Since housing is a human right, the replacement and reconstruction of a house within several months is important. If, hypothetically, we defined as a goal the ability of households to reconstruct their faced housing damage through their own monthly income within three months, more than 60 percent of the households in the selected GN Divisions would be classified as being prone to unusual difficulty in recovering from the negative impacts of the Tsunami. This number might be even higher if we acknowledge a general decline in income after the Tsunami. The index is meant to visualise unusual difficulty in recovering among different social groups or between different areas; it is not intended to calculate the exact time one household would need to recover, although the data is generated and calculated on individual and real households affected by the Tsunami.

In order to analyse the recovery time of different occupational groups in different areas, we used the occupation of the household head and the land title as important criteria in distinguishing social groups. With regard to occupation, the calculation shows that households where the head was working in housekeeping or as a fisherman had major problems recovering (see Figure 22). The housekeeping households would need, for example, more than 32 months to replace their actual housing damage, whereas households in which the head was a clerk, fish-seller or executive officer recovered much faster and needed on average only half a year or less to replace their faced housing damage.

Figure 22: Recovery index by occupation of the household head: Galle



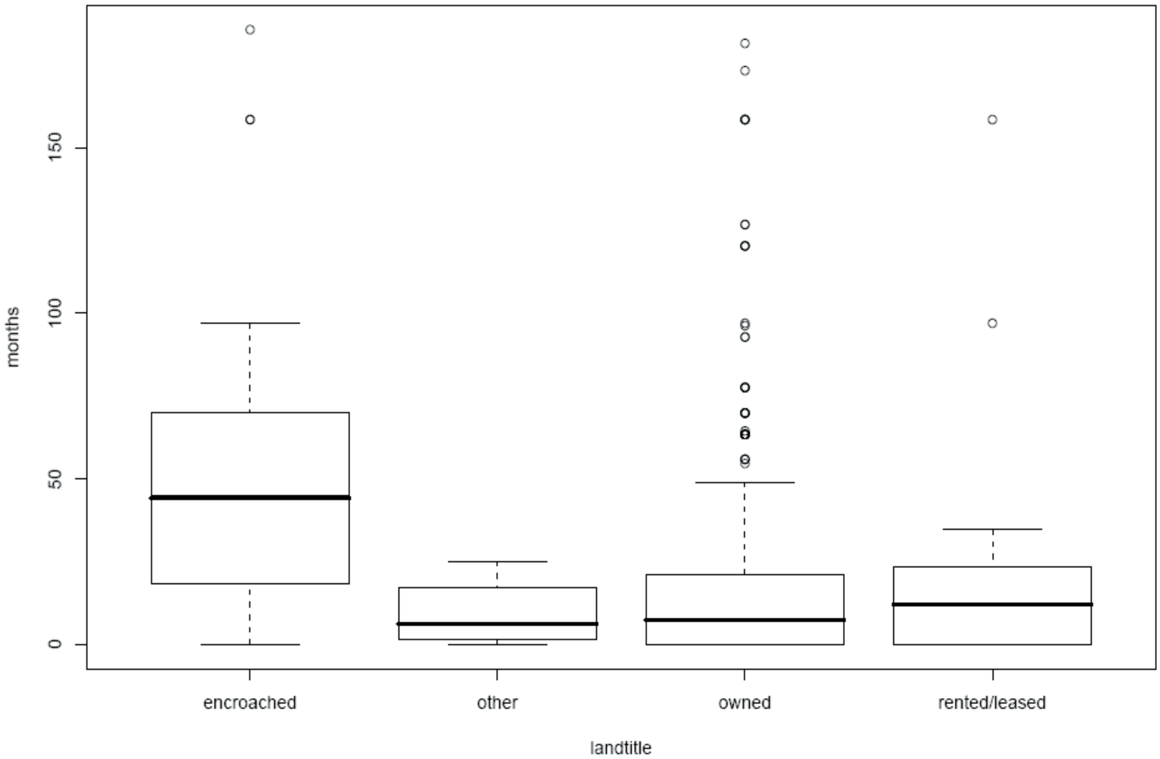
Source: Birkmann

Interestingly, households where the head is a technical assistant are a relatively vulnerable group; however, in our questionnaire-based research this group was not exposed in the 100m zone. Over-exposed proportionally in the 100m zone were those households where the head was engaged as a driver, hotel worker or fish-seller. Households where the head was a clerk or technical assistant were less exposed. Figure 22 underlines the different categories of households according to their recovery potential based on their job-profile (occupation).

Recovery and land title

Analysis of the recovery process of different groups with regard to their land title shows that households living on owned land need around seven months to replace their experienced housing losses, while in contrast the group of squatters (encroachers) need on average around 44 months to replace their actual housing damage, based on the median (statistical average – excluding extreme values). The group of people living in rented houses need to spend around one year of their free available income to replace their housing damages (see Figure 23, below).

Figure 23: Index applied to house damages and land title



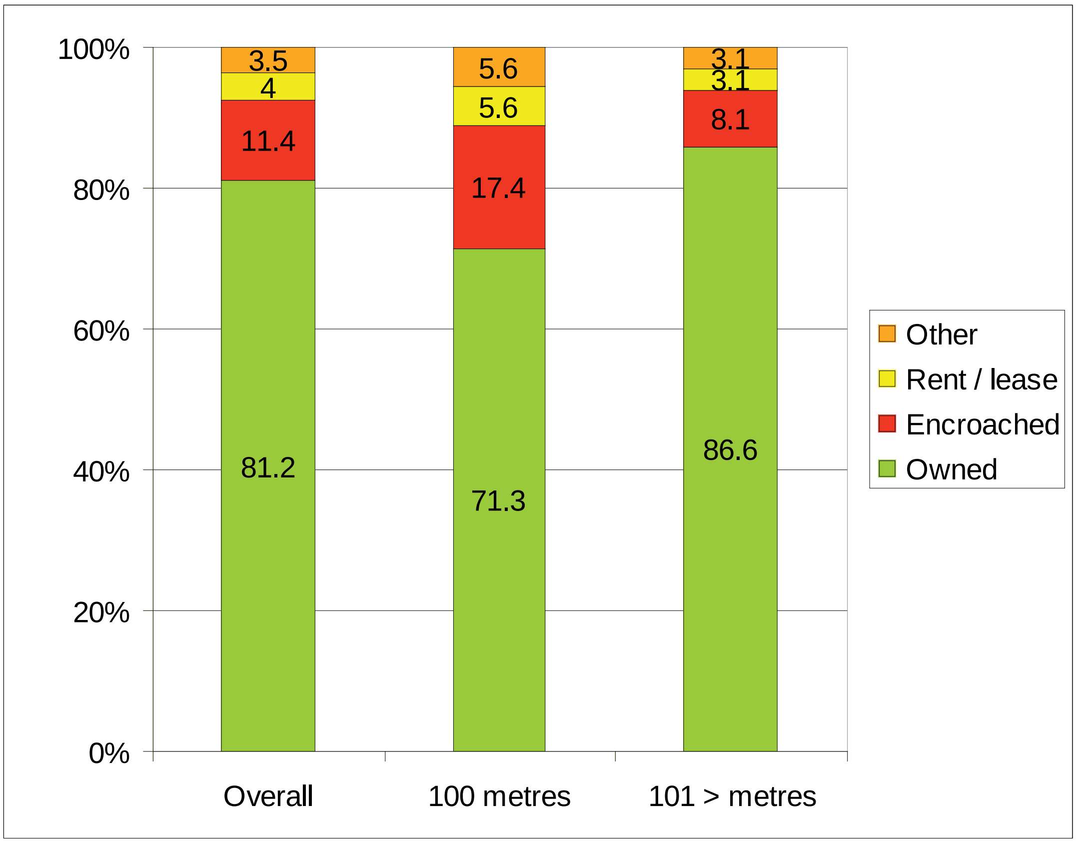
Source: Birkmann

The clear differentiation between the recovery potentials of different social groups according to their land title already indicates that land ownership itself can serve as a surrogate indicator of vulnerable households and to estimate the resilience of different social groups in Galle.

Land ownership is a key aspect of vulnerability to coastal hazards and tsunamis in Sri Lanka, since access to legal land for housing is not available for poor urban households because of the high commercialisation of the housing and land markets. Using land ownership as an indicator allows identification of social groups that are highly vulnerable, since it serves not only as a legally accepted place to live but also as an economic and livelihood resource – in other words as a place for production, security for bank loans and even as something to be sold in times of crisis (Farrington et al. 2002; Satterthwaite 2000). It is assumed that households that live near the sea (exposure) and do not own land (squatters in particular) are especially vulnerable due to their unusual difficulties in recovering from potential tsunamis or coastal hazard impacts. At present they are not allowed to rebuild their houses in the same place; nor to receive financial support from the government to rebuild inside the buffer zone (see also Chapter 7).

Having said that, the analysis of land ownership in the six selected areas in Galle shows that a significant proportion of respondents did own land (81.2 percent), while nearly 11.4 percent encroached either on government or private land. Although people with no land title constitute around 10 percent of the total population in this area, a significantly higher proportion of encroachers and illegal settlers live within the 100m zone (17.4 percent) compared with the average (11.4 percent) (see Figure 24). The number of squatters in the 100m (high-risk) zone is twice as high as the number of squatters in the 200m and 300m zones. This implies that a higher proportion of people within the 100m zone are highly vulnerable.

Figure 24: Land ownership and spatial exposure in the selected GN Divisions: Galle

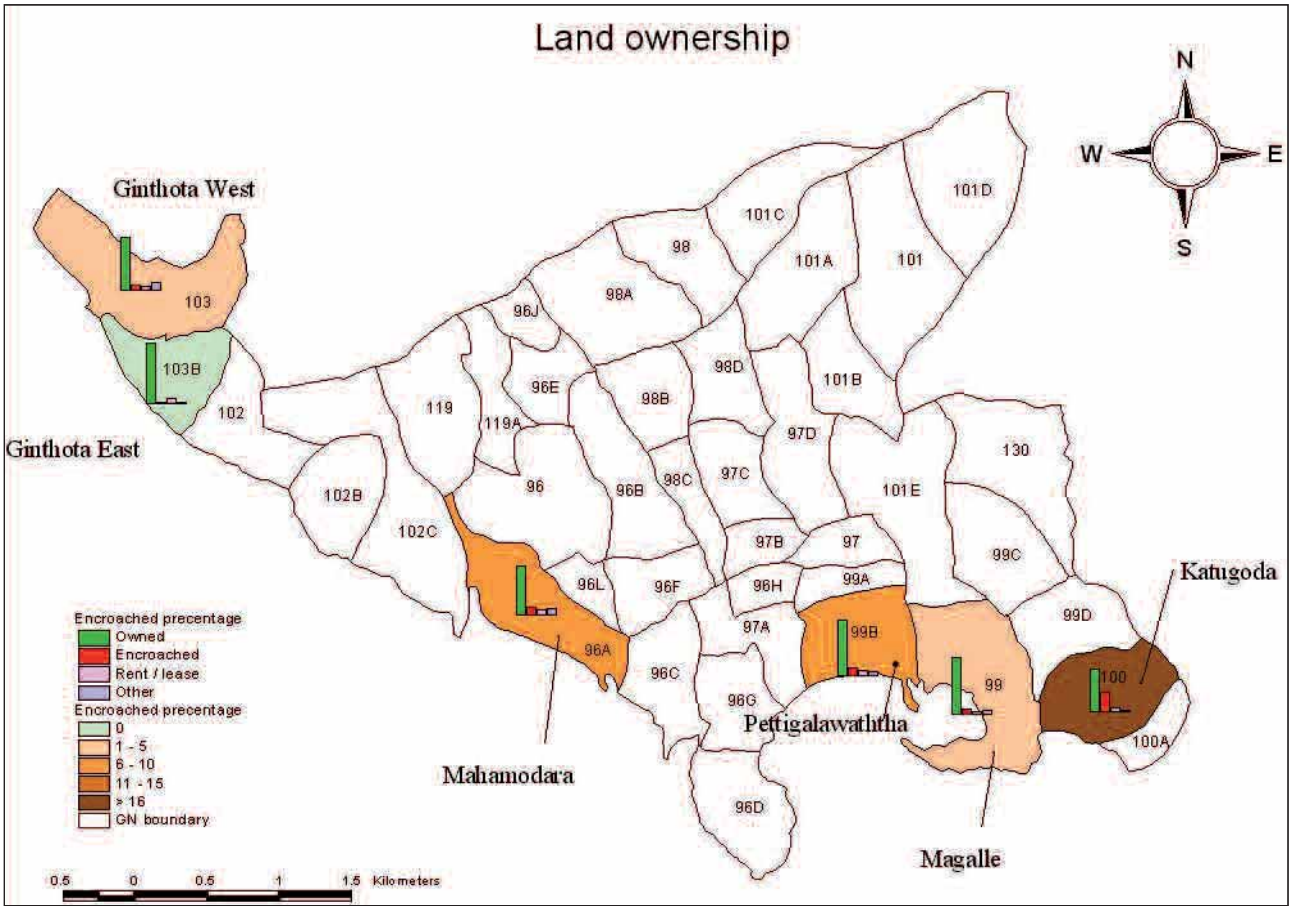


Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

It became evident that nearly 87 percent of squatters' housing units situated within the 100m zone were totally destroyed by the tsunami compared with those situated outside this zone (46 percent). Lack of land ownership and the low standard of squatter housing units are root causes of why nearly half of these people still live in relief camps or temporary shelters provided by the government and NGOs. When people in the buffer zone are resettled, those who had legal titles can continue to claim their property and use it for purposes other than construction; squatters do not have this opportunity.

The pattern of land ownership varies among the six field locations. The highest proportion of encroachers can be found in Katugoda (28.6 percent), whereas there are no encroachers at Ginthota East captured within the questionnaire-based survey (see Figure 25). Moreover, Pettigalawaththa and Mahamodara indicate a higher number of encroachers than Ginthota West and Magalle. Therefore, special attention to the problem of relocation and rehabilitation is needed, especially in Katugoda.

Figure 25: Land ownership and encroachers in the six GN Divisions: Galle



Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

It can be concluded that the indicators 'amount of young and elderly people' (0-9 and 40 plus), the exposure of a unit or element at risk (e.g. social group or infrastructure/sector), gender distribution, income level, membership of an occupational group and land ownership have an important impact on the vulnerability of various households.

While gender, age and exposure are primarily linked with susceptibility, the ability to overcome long-term impacts and to recover reflect more precisely the interface between susceptibility, coping capacities and recovery. Some households will not be able to repair their houses on their own for a long time, so they still have to cope with the secondary impacts of the tsunami, whereas others are already reconstructing their property and may bounce back in a few months. Interestingly, the results in Galle show that the opportunities for a household to recover relatively quickly depend on factors such as the exposure of the household in the event, the size of the household, income level, job diversity within a household, and land ownership. The combination of these criteria can be especially valuable in estimating and identifying the most vulnerable groups and areas such as Katugoda in Galle, but also in transferring these indicators and assessing vulnerability in cities not hit by the tsunami but potentially at risk.

Coping capacities and social networks

When looking at how tsunami-affected people cope, social assets – such as networks, memberships of community-based organisations, relationships of trust and reciprocity, access to wider institutions in society – play an important role (Carney 1998). Therefore, it is important to examine if there is any advantage of being a member of a local organisation. A significant proportion of household members interviewed were not members of local organisations. As a result, only 6 percent of community members gained financial assistance from local organisations to recover from the tsunami. Regarding counselling or psychological support of community members, the data shows that only 5 percent received such support. Therefore, one can conclude that only a small proportion of community members receive financial assistance and counselling or psychological support from village-level organisations. In contrast, nearly 98 percent of respondents have received different types of aid in cash and kind from various UN agencies such as UNDP, UN-Habitat and other government and non-governmental organisations for various purposes to recover from the tsunami. Therefore, it seems that membership of a local organisation alone is not an adequate indicator in assessing the coping capacities of different households and household members in Galle. However, when the tsunami first hit it was neighbours (55 percent), friends (10 percent), and relatives (18 percent) who first came to help the affected people, before other authorities – which shows the close relationship they maintain with these people.

Another important aspect of coping capacities is a saving account since it helps households to recover from, or lessen the impact of the disaster. Thereby it does not matter, whether the saving money is being saved in formal ways (with government, private or non-governmental organisational banks) or informal ways (in tins or 'seetu' – a small group-saving system in Sri Lanka). The questionaire has shown further, that three-quarters of respondents (75 percent) own saving money; and the majority confirmed of having a savings account.

Table 4: Sources of loans after the tsunami in selected GN divisions: Galle

	No	**%**	**Valid %**
Friends/relations/neighbours	42	8.4	44.2
Informal money lender	9	1.8	9.5
Banks	30	6.0	31.6
NGOs	5	1.0	5.3
Commercial society	9	1.8	9.5
Total	95	19.0	100.0
N/R	405	81.0	
Total	500	100.0	

Source: J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe

The data also shows that a significant proportion of respondents have not taken loans to recover from the tsunami (81 percent), since major support was channelled through international aid and disaster agencies, as well as through the government, owing to the extraordinary magnitude of the catastrophe. Of those who have taken loans, 44 percent have taken loans from their relatives, neighbours and friends, while another reasonable proportion (nearly 32 percent) have taken loans from the formal banking system (see Table 4).

6 Vulnerability Comparision between Galle and Batticaloa based on the Household Survey using Questionnaires

by T. Jayasinghem and J. Birkmann

6.1 Introduction: Background Batticaloa

Batticaloa is the principal city of the Batticaloa district on the East Coast of Sri Lanka, with 75 sq km of area divided into 48 GN divisions (see Figure 27). For administration purposes the area is known as the Manumunai North DS divisions, and for local governance it is the Municipal Council of Batticaloa. The area is connected land-wise with Eravur Pattu in the north and Manmunai Pattu in the south. The sea borders one side and the other side is bordered by a lagoon which is profusely branched. The northern and southern sectors are linked by a bridge at Kalladi, which was built around 1870 and is the main link to the North (Polonnnarouwa, Colombo) and South (Ampara, Kataragma). The entire area is flat with hardly any land exceeding 2m in height above mean sea level.

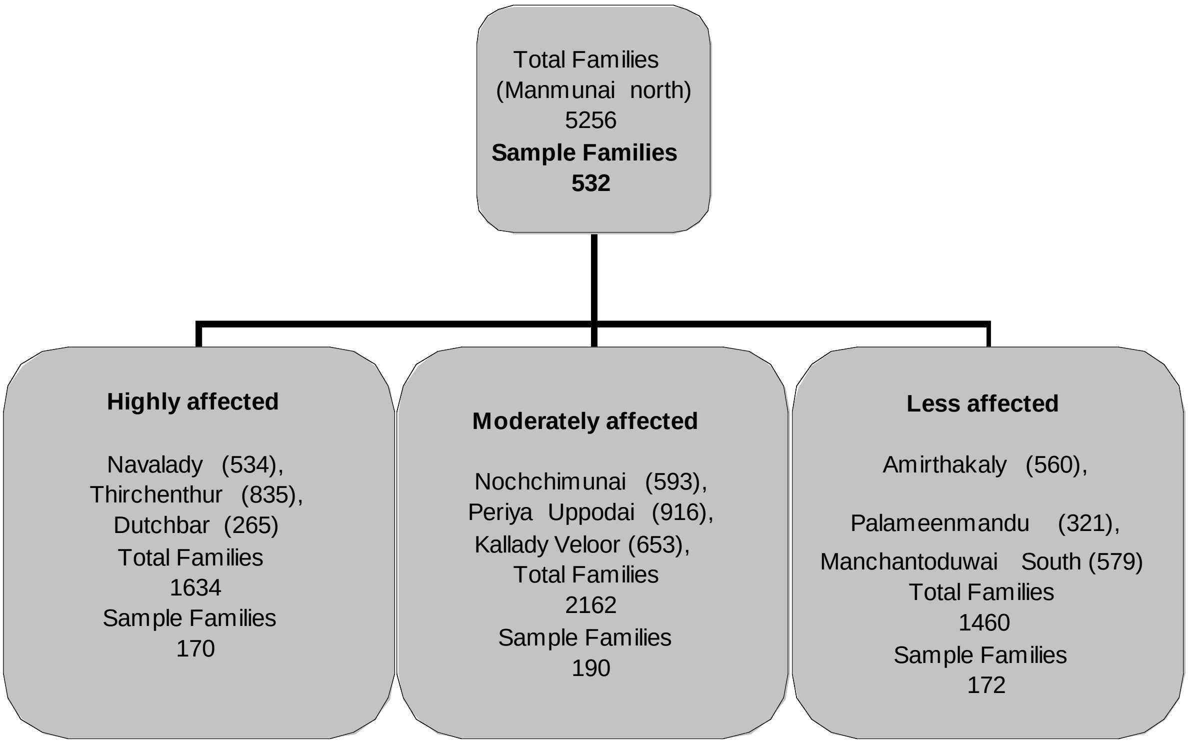
Batticaloa City has a population of 85,557 in 22,767 families (Statistical Handbook 2004, Batticaloa District) and is classified as urban. Agriculture is the dominant livelihood of the district, with fisheries following second. However, Batticaloa City has fishing (sea and lagoon) as its principal livelihood, followed by government employment, business and services/ labouring. The city has a teaching hospital, three private hospitals, numerous government and private bank offices, many schools (including two national ones), a main post office, a bus station, a railway station, a telecommunications office and numerous international NGO offices, including the UN. It is a regional centre in the East of Sri Lanka that bears close comparison with Galle in the South in terms of status and function. The tsunami that struck the coast on 26 December 2004 devastated the entire city of Batticaloa. Eighteen of the 48 GN divisions were damaged significantly, eight of which were totally destroyed; 1,472 people died, 942 were injured and 630 went missing; 15,600 families were displaced. Livelihoods were extensively interrupted. Most of the displaced people were accommodated in schools at first, after which they moved to temporary shelters where most remain today. Some lived with friends and relatives and have either returned to their places/ new places or left the city.

6.2 Methodology

In principle the methodologies used in Galle (see Chapter 5) were also applied to Batticaloa with regard to the structured, questionnaire-based household survey. However, due to two decades of armed conflict in the region, some adjustments had to be made to reflect the true ground situation. In contrast to Galle the census data for Batticaloa is relatively weak. Therefore the sampling was random in each GN division, starting from a point and collecting information from all the neighbours until the required number of households was reached. However, many houses did not have anyone on site because they were in shelter camps or elsewhere. The survey team traced them as far as possible, with the assistance of the Grama Niladari, to get the interview. But if the family was missing or unable to be traced then the next family was taken in. In Navaladi, where 100 percent of the houses were totally destroyed, all interviews had to be held outside. It was also difficult to establish who lived next door; the villagers' and the GN officers' observations were used to sort this issue out satisfactorily.

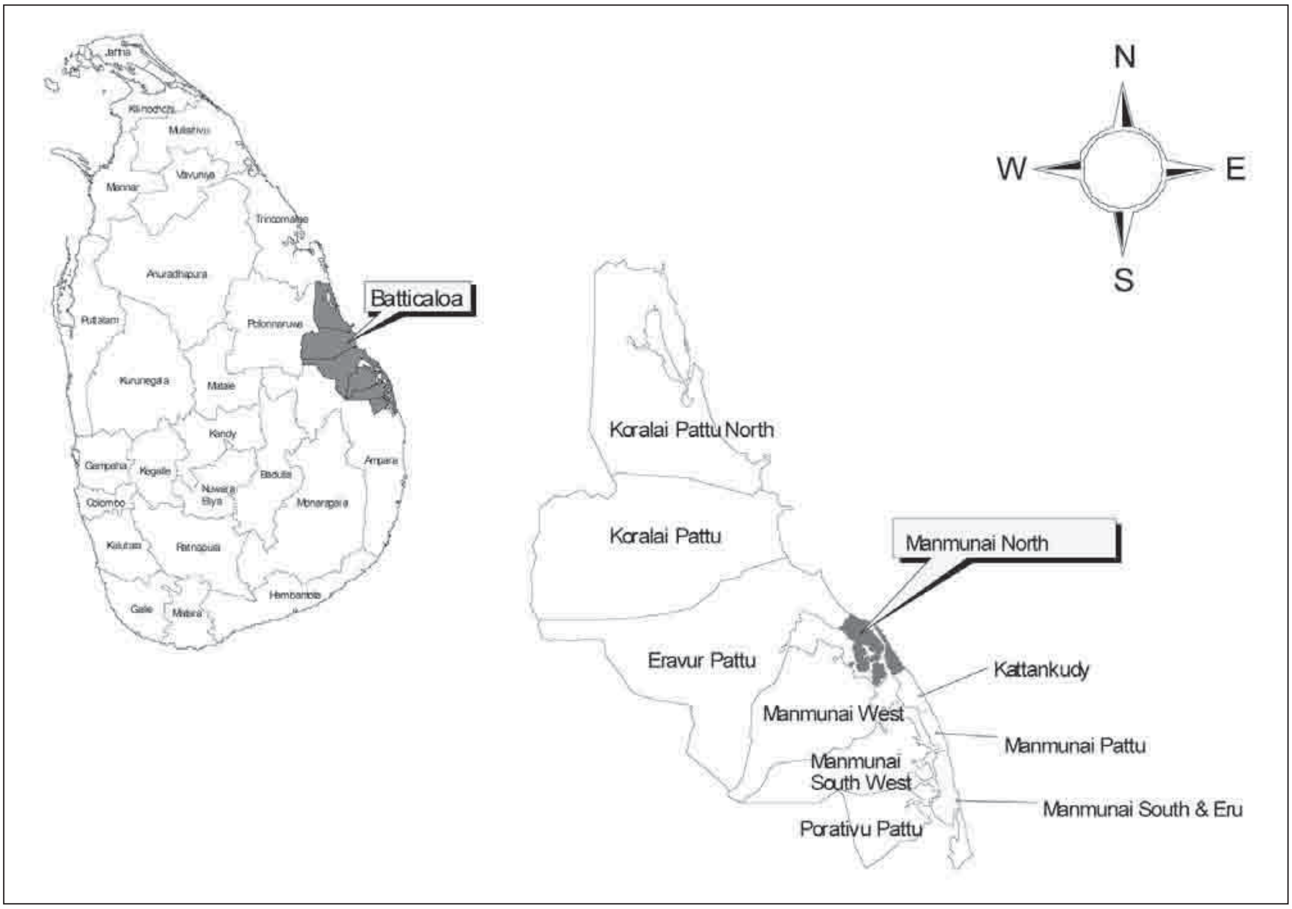
The questionnaire-based identification of vulnerability and most vulnerable groups was adopted in the nine GN divisions shown in Figure 28. Eighteen GN divisions out of 48 were damaged, and most of them were on the coast. In selection of the nine GN divisions the extent of damage to houses was considered and three levels of damage were chosen – high, medium and low – with three GN each for sampling purposes. 532 families were interviewed in total, as indicated in Figure 26.

Figure 26: Structure of the sample in Batticaloa



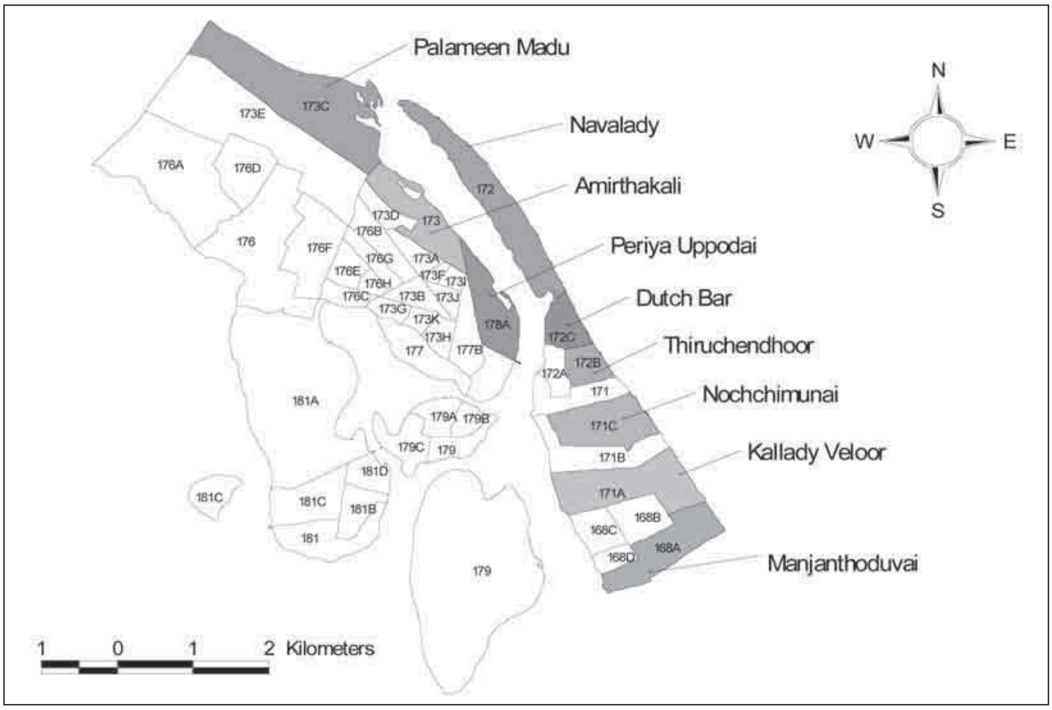
Source: T. Jayasinghem and J. Birkmann

Figure 27: Overview of the location of Batticaloa and the selected divisions



Source: Nandana

Figure 28: Overview of the selected GN divisions in Batticaloa



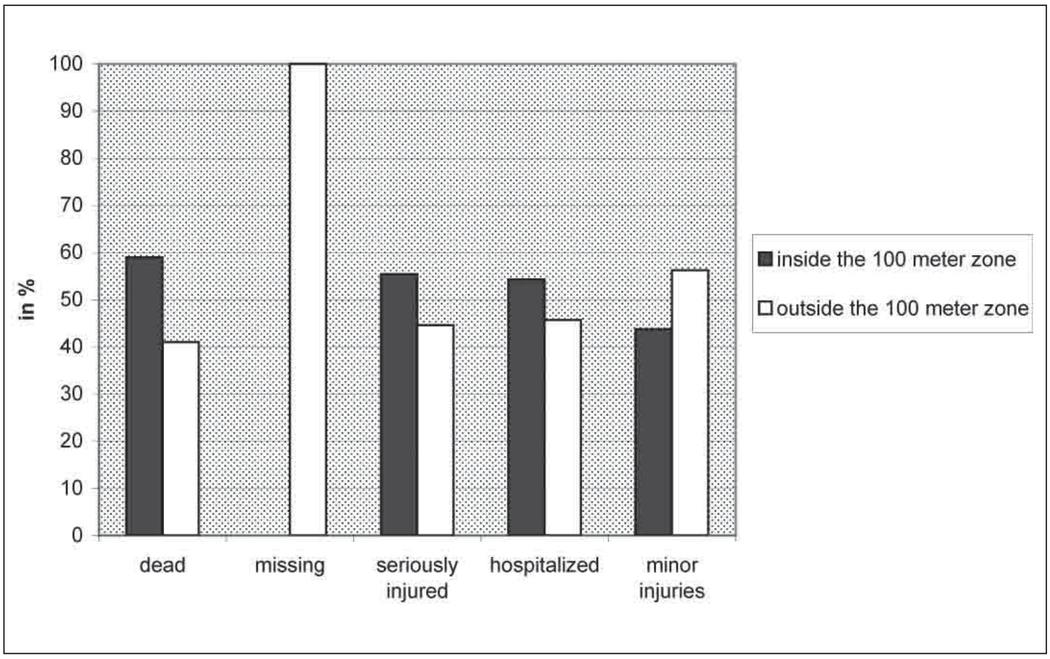
Source: Nandana

6.3 Selected Results

6.3.1 Exposure

With regard to the human impact the analysis of data taken from the household survey in affected GN divisions in Batticaloa shows that death within the 100m zone was twice as high as outside the zone (see Figure 29).

Figure 29: Human impact inside and outside the 100m zone, in selected GN divisions: Batticaloa



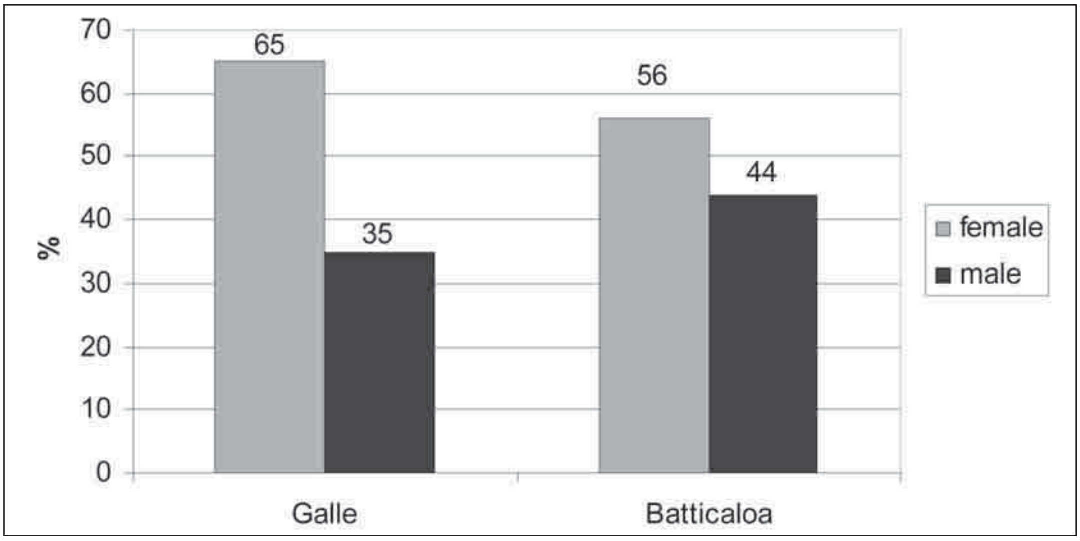
Source: by T. Jayasinghem and J. Birkmann

Major fatalities were also reported outside the 100m zone, and the tsunami wave went much further inland than in Galle. Differences between Batticaloa and Galle can be explained by the timing of the event and the physical and geographic structure. Overall, the impacts of the wave were much more severe in the selected GN divisions in Batticaloa. This was because the waves hit the coast directly, unlike in Galle, where the higher waves were a combination of direct waves and, much later, reflected waves. Also, the beach is flat and open in Batticaloa with a relatively low density of built environment.

6.3.2 Susceptibility

Analysis of the number of dead and missing revealed, for Batticaloa as well as for Galle, that fatalities in the tsunami were far greater among females than males (see Figure 30).

Figure 30: Dead and missing according to gender in Galle and Batticaloa



Source: by T. Jayasinghem and J. Birkmann

While males account for 44 percent of the dead and missing, females account for 56 percent, more than 10 percent more. Many reasons have been given for this from the observations of rescue teams and comments by survivors:

- More women were at home looking after routine domestic activities;
- When the tsunami hit, women caught by the waves got their dresses (sarees) and hair entangled with objects in their path (fences, trees, etc) causing death;
- Women were trying to look after children and were delayed at home after being warned, while others were fleeing; and
- Women tried to lock up houses and collect precious items, which delayed them moving out.

Examination of the dead and missing by age group also revealed that small children were highly vulnerable in terms of the absolute number of fatalities (see Figure 31).

Figure 31: Dead and missing according to age in Batticaloa

Batticaloa age group	Absolute number of people killed in the age group	Relative number	Relative mortality by age group	Absolute number of people in age group
0-10	36	38%	8%	427
11-20	15	16%	3%	468
21-30	9	10%	2%	442
31-40	11	12%	3%	368
41-50	8	8%	3%	270
51-60	4	4%	2%	182
61-plus	11	12%	11%	102
	94	100		

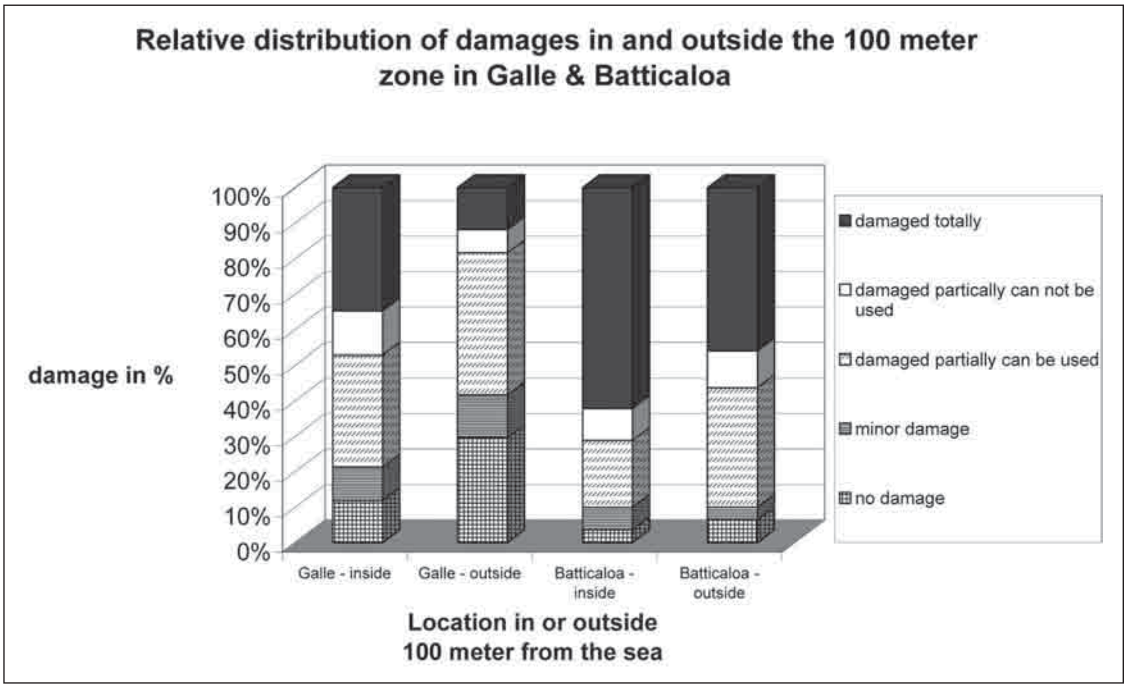
Source: Birkmann

The proportion of deaths within the age groups is calculated and given in column 4, and this indicates that death was highest in the 61-plus group, with 11 percent, and in the 0-10 age group, with 8 percent. All other groups were below 3 percent, which indicates that these two groups are more vulnerable than all the other groups.

6.3.3 Destruction of the Build Environment

Regarding the physical damage of the build environment, the number of houses totally destroyed is much higher in Batticaloa than in Galle, inside as well as outside the 100m zone (see Figure 32). Batticaloa reported 3,678 houses totally destroyed, of which 1,232 were within the 200m zone and 2,446 outside the zone. Partially damaged houses outside the buffer zone totalled 1,184.

Figure 32: Relative housing damage inside and outside the 100m zone: Galle and Batticaloa



Source: Birkmann

In Navaladi GN division 100 percent of the houses were totally destroyed. The houses in the front line were smaller, isolated and only had a thin fence of Paymyrah petioles covering them, a few having barbed wire. This was easily destroyed and allowed the waves to damage houses much further inland. Similarly, the funnel affect of the lagoon directed the wave's interiors and caused heavy damage in places such as the Amirthakali GN division. Houses further away from the beach were generally larger and had more stabilised constructions of parapet walls, which took some of the force out of the waves, explaining the fact that most houses in that section were damaged but can still be used, as in Galle. When there were larger houses in the front line (closer to the coast) with parapet walls, these structures took the pressure and in effect protected the interior, and as a result the damage further inland was lessened in some divisions.

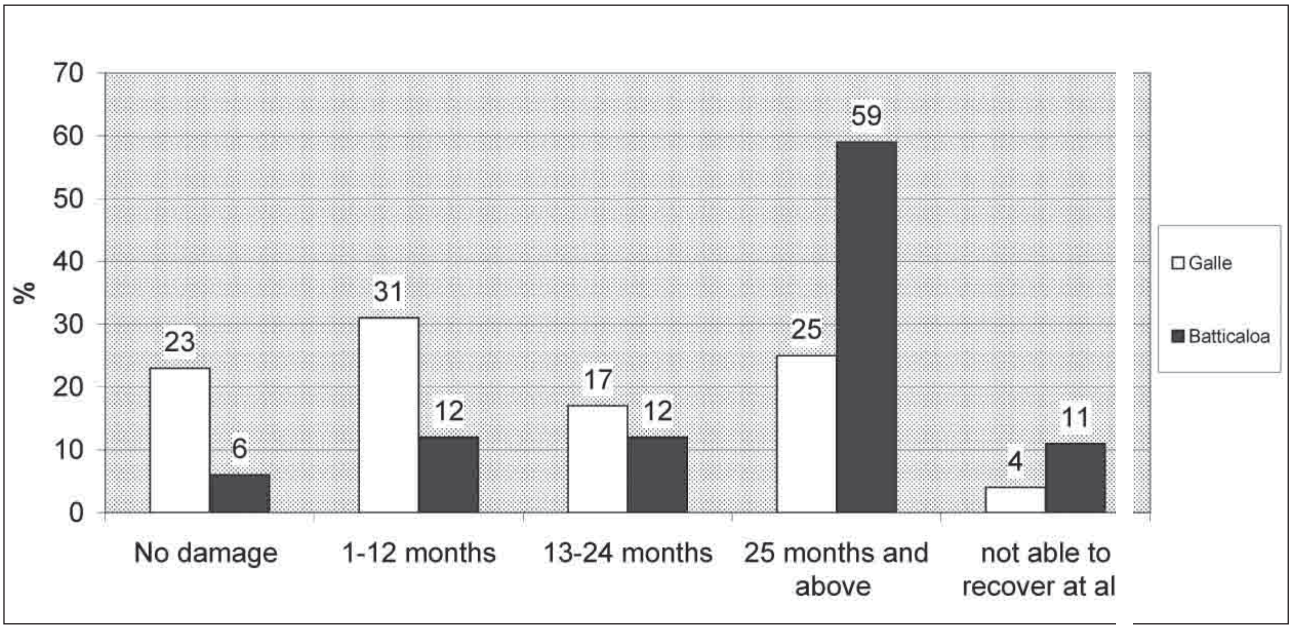
Overall, in contrast to the findings in Galle, it is evident that in Batticaloa the heavily damaged area goes far beyond the first 100m from the sea (see e.g. Figure 32). Around 50 percent of the households captured in Batticaloa outside the 100m zone reported that their house was totally destroyed. This implies that a general 100m or 200m buffer zone does not fit with the specific local context conditions, which should be taken into account in order to ensure the effectiveness of these measures and interventions.

6.3.4 Coping and Recovery

Coping and recovery are essential issues facing an individual, household, community and society in relation to any disaster. Coping is the mechanism by which people are able to reduce effectively the impacts of the disaster and facilitate their lives as far as possible. Recovery relates to the activities which bring back the status quo of the affected populations. Quick recovery puts the population back on the track of development, and the slower the recovery the more difficult it is for the community. Secondary, the psychological and personal factors (e.g. dignity, dependence) also have a serious impact on the entire system. In the Sri Lankan context, 'own house' is a symbol of household, dignity and privacy. The loss of a house causes tremendous trauma to the family, and until they get it back the psychological trauma remains. Therefore, getting their house back or rebuilding it becomes a major recovery issue. At the time of this study no permanent houses had been constructed and handed over to the affected people, and most of these people remained in temporary accommodation. Overall, the potential recovery time in terms of the householders' reconstruction of their house is an important indicator in measuring their ability to return to normal life.

Figure 33 shows potential recovery time in Batticaloa as compared with time taken in Galle to overcome actual housing damage. It shows significant differences in potential recovery time between households in Batticaloa and Galle. If we compare the number of undamaged households with those needing more than two years to recover and those unable to recover at all, it becomes clear that around 30 percent of the households captured in Galle either need more than two years to recover, or are unable to recover at all. By contrast, the same categories in Batticaloa accounted for 70 percent of the households. This means that around 70 percent of the households in Batticaloa are unable to recover by themselves in an appropriate time period, even though the replacement values for the housing damage are calculated on the basis of a relatively low-cost reconstruction type (250,000 rupees).

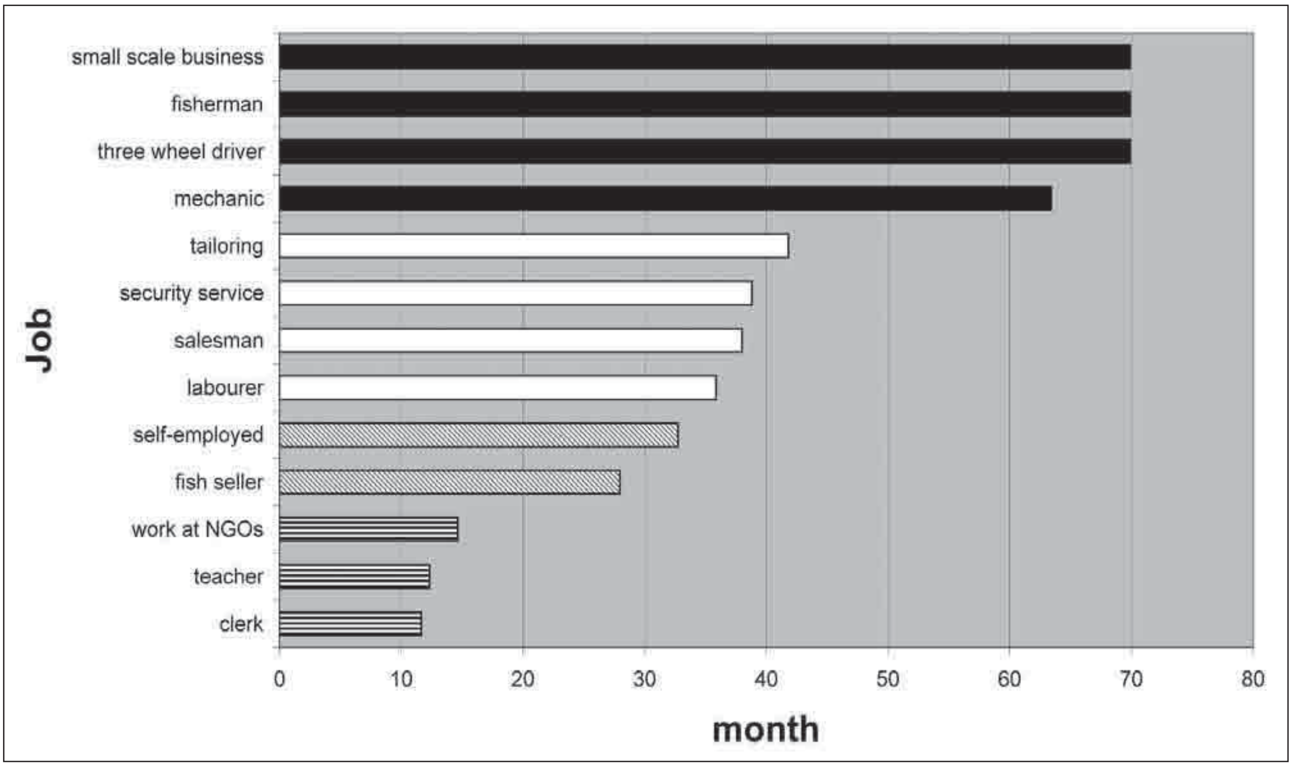
Figure 33: Unusual difficulties in recovering: Galle and Batticaloa compared



Source: Birkmann

The major differences are not solely caused by the different levels of urban density or the hazard magnitude, but also the result of limited access to a wider job market (significantly lower job diversity and the smaller household size in Batticaloa than in Galle) and the relative low income. This also relates to the fact that Batticaloa has been subjected to armed conflict over the past two decades. With conflict-related uncertainties in the region, openings for employment are very limited. The difficulties of different households to recover can also be examined according to their job profile, using the occupation of the head of household as the classification criterion. Analysis focused on the occupation of the household head, accepting that in some households more than one person contributes to the household income. Our hypothesis was that there are differences in terms of the potential recovery time of those households working primarily in fishing compared with households in which the household head works as a clerk, for example, or is in business. The analysis for Galle shows that households engaged in housekeeping – those earning their income through domestic work (full or part-time) such as washing clothes, cooking, cleaning and gardening – are one of the most vulnerable groups with regard to their difficulties in replacing actual housing damage. These households need more than 32 months (2.6 years) to repair or replace their actual housing losses (average/ median). By contrast, households where the head of the household is a clerk, executive officer or fish-seller are able to repair or replace their actual housing damage within half a year or less.

Figure 34: Unusual difficulties in recovering: Batticaloa



Source: Birkmann

Interestingly, the profiles of the most vulnerable households differ between Batticaloa and Galle. This means that not only incomes but exposure and household composition might be different in the two cities (Figures 33 and 34). All the households in Batticaloa on average (median) need more time to recover than those in Galle. Furthermore, analysis shows that the most vulnerable groups in Batticaloa are households where the household head is a small-scale businessman, fisherman or three-wheel driver, while those households in which the head is a clerk or a teacher have a higher coping capacities – in other words they potentially recover faster from their actual loss (see Figure 34). Thus the group of households with a relatively good recovery potential show some similarities in Galle and Batticaloa. Generally speaking, households where the head is a clerk, teacher or executive officer are able to recover faster than those where the head is a fisherman, is employed in housekeeping or, in the case of Batticaloa, is in small-scale business. The underlying reasons may be manifold –size of household, age structure, job diversity, etc.

The results also indirectly reflect the 'stability of the employment' where the clerk, teacher or NGO-worker who have a permanent job are able to earn a steady income, while small-scale businessmen, fishermen and three-wheel drivers often only have temporary income. The number of people involved in small-scale businesses has increased during the conflict in Batticaloa. These people have little basic capital, which explains their vulnerability as an occupational group.

Coping capacities in Batticaloa

In contrast to the situation in Galle, coping capacities have been eroded in Batticaloa as a result of the 20-year-long conflict that has seen repeated occurrences of violence and displacement. With the Ceasefire Agreement (CFA) in February 2002 the communities had a chance of stability, but from 2003 onwards and by the time of the tsunami in 2004, the conflict intensity and violence increased dramatically.

Regarding the involvement in local organizations (formal networks as part of coping capacities), Batticaloa shows similar tendencies as Galle. The number of people formally involved in those local organisations is low (4.3 percent). According to field reports, people have little affinity with these organisations, except for the fishermen's societies, which support income and loans. Also, with regard to financial support, most respondents have received aid of various types from UN agencies and international NGOs. Membership of local organisations did not play a significant role here.

Coping capacities can also be related to the option of formal and informal money-saving. While in Galle 75 percent of respondents answered that they have a bank account, this number was significantly lower in Batticaloa, where only 37 percent claimed to have one. From our own observations in Batticaloa we assumed that the majority of people who work for the government or who have permanent jobs also have bank accounts, and are operating their finances through a formal banking system. This implies that many people in Batticaloa captured within the questionnaire research did not have savings. Only 34 percent of the households interviewed indicated that they did. This also explains the fact that the sources of loans to recover were nearly all distributed and secured through external help and aid organisations. Around 94 percent of the people captured were depending on financial aid.

In addition, less than 4 percent of the households reported that they had received counselling and/ or psychological support. Based on local knowledge and our research we can conclude that counselling has not been a prominent part of the recovering strategy during the conflict and with the tsunami. On the other hand, rural communities outside Batticaloa reported that they had received counselling from elders and betters, relatives and others.

Knowledge of the tsunami

When examining the coping capacities of tsunami-affected people, education and knowledge about the hazard is an essential aspect. Recognition of the danger is a prerequisite for the ability to activate evacuation and coping mechanisms. Our hypothesis was that people who had heard about tsunamis and coastal hazards before 26 December 2004 were better able to cope with the event than those who did not have any experience or knowledge of them.

Analysis revealed that in Galle and Batticaloa only around 8-10 percent of respondents had ever heard about tsunamis. Indeed, around 90 percent of household members interviewed answered that they had never heard of tsunamis. Another study undertaken by the Asian Disaster Reduction Centre (ADRC), with a similar question as to whether people had heard about tsunamis before the disaster (Kurita 2006), focused on schoolchildren, teachers and residents of Galle. The study revealed that more than 90 percent of respondents had never heard of tsunamis. Moreover, the ADRC study included the question whether respondents thought that if they had known more about tsunamis before they would have been able to reduce the damage in the event. Nearly 90 percent of people interviewed answered 'yes'. Thus, familiarisation with past tsunamis and other coastal hazards – and equally education on vulnerability to potential risks – is, in our view, an important element in increasing the awareness of these threats to human life, in order to minimise possible losses and negative impacts from tsunamis in the future.

7 Identifying Vulnerability Using Semi-structured Interviews

by S. Amarasinghe

7.1 Introduction

Semi-structured interviews were conducted in Galle municipality area in order to analyse the issues identified in the household survey related to vulnerability, coping capacities and intervention tools. These interviews focused on different occupational, social and ethnic groups, such as fishermen, Sinhalese and Muslim ethnic groups, and people living in temporary houses and resettlement areas.

In-depth interviews were conducted with selected families in the area. Those families were noted during the household survey using structured questionnaires (see Chapters 5 and 6) for the unique experiences they have had with the tsunami. Key informant interviews were also conducted with GN officers and development officers working in the area. Three methods were adopted in collecting qualitative information:

a) In-depth interviews with selected families;

b) Focus group discussions (FGDs); and

c) Key informant interviews.

Table 5: Overview of semi-structured interviews and focus group discussions: Galle

Method	Selection Criteria	Number of Interviews
In-depth interviews with selected families	a) Intensity of damage (high, moderate and low)	3
	b) Livelihood (fishing, self- employed, unemployed, women- headed)	4
	c) Settlement pattern (living in camps, transit and permanent houses)	3
	Total	**10**
Focus Group Discussions	a) Administrative officers	1
	b) Minority groups	1
	c) Youth	1
	d) Women	1
	Total	**4**
Key informant -interviews	a) Government officer	1
	b) Non-government officer	2
	Total	**3**

Source: S. Amarasinghe

Focus of the analysis

The main parameters in conducting in-depth interviews were the current problems people faced; settlement options; employment preferences; sense of vulnerability; sense of powerlessness; knowledge of early warning; views on relief measures; community participation; and access to information and gender equality.

7.2 Damage to Squats in Galle Municipal Area

Prior to the tsunami, there were 75 poor Muslim families living in squats scattered along the railway line, known as CGR Watta. All these houses were temporary units and most of them were constructed with wooden planks. The main economic activity of many of these families was in the informal sector, such as petty trade, paid labour and fishing. Even though all their houses were totally destroyed, house-owners were not granted compensation because they were squatters and the land was located in the 100m buffer zone. Some families moved on to other locations, leaving 55 families in the area. The Sevalanka Foundation, a NGO working in the district, helped these families. Each one was given a temporary house made of planks/ temporary material and thatched with metal sheets. Houses of about 200 sq ft in size and without rooms seemed quite insufficient for the requirements of five to seven members of an average family. Almost all the members of this community hope to have permanent houses built in the same place, as it allows them their informal-sector income in the city. Also, being Muslims, they wish to live alongside their neighbours and close to a mosque.

7.3 Damage to Economic Activities and Livelihood

Economic activities in the affected areas were mainly based on various geographical and situational factors. In Katugoda there were large numbers of unauthorised settlers and poor families who earned money in petty trade, labouring and self-employment. Some women had been supporting the family through the preparation of sweetmeats, breakfast food and working as housemaids nearby. The damage to their houses and equipment, and the destruction in the urban centres, affected their day-to-day living considerably.

In Magalle and Katugoda, which were heavily affected, people had been living in relatively better economic conditions through their involvement in the fishing industry. The majority of those families were living in permanent houses and fishermen had personally owned boats and fishing gear. Traditionally, womenfolk in the area had been involved in lace making. The damage caused to boats and fishing gear during the tsunami had a serious impact on their income. With the help of a foreign organisation (see Chapter 5), some families in the area were able to buy boats and continue fishing. Others found work labouring and in petty trade or became unemployed. Lace-making was disrupted due to the damage caused to equipment and the loss of the market.

Inhabitants in Pettigalawaththa and Mahamodara, where the tsunami had less of an impact, had been involved in different work. Since Pettigalawaththa is close to the commercial area of the town, many families were involved in medium and small-scale businesses, such as retail shops, vegetable shops, hardware shops and small restaurants. Some had also been involved in animal husbandry. The damage to business premises and enterprises was a serious setback for these businessmen. Some were able to restart their business with their savings and credit facilities, but many are still suffering due to a lack of capital.

Mahamodara is in an area where many public institutions such as the district hospital, nursing school and prison are located. Accordingly, people in the area were either directly or indirectly linked with these institutions for their income. Some worked as labourers, drivers and watchers; others provided accommodation and food, or ran small-scale grocery stores and restaurants. Women in the area were mostly involved in dressmaking, sweetmeat making and providing boarding. The tsunami caused damage to the incomes of all small-scale enterprises, self-employment and labouring. The income available providing food and board was also greatly disrupted due to the damage caused to houses and the displacement of families. The Ginthota East and West areas were inhabited by relatively well-to-do families and suffered mild damage by the tsunami. They included medium and small-scale businessmen, fishermen, government and private-sector employees and labourers. As the number of families affected by the tsunami was limited, the disturbance to economic activity was also found to be marginal. Some families whose businesses were damaged by the tsunami were able to re-establish them with their own capital.

7.4 Ethnic and Religious Affiliations

Focus group discussions conducted with affected families revealed that existing relations within the communities were largely helpful in encouraging cooperation between people in the disaster situation. The religious affiliations and bonds in these communities were instrumental in providing immediate assistance. Initially, almost all families falling victim to the disaster were given shelter at religious centres in the vicinity, such as Buddhist temples, mosques and churches. There were no ethnic or religious differences considered in providing shelter. Sinhalese, Muslim and Hindu families found shelter in Buddhist temples and vice versa. Accordingly, social relations and bonds between various ethnic and religious groups were strengthened in the early stages of the disaster.

Families looked after by religious organisations were at first provided with food and other basic requirements by their non-affected relatives, neighbours and philanthropists in the vicinity. This was mainly because there were no access roads for outside assistance due to the destruction of the road network. Also, some political groups and youth groups in the locality had helped to provide medical treatment and direct people to nearby camps. However, after the clearing of access roads, help from government organisations and NGOs as well as groups from other parts of the country reached affected families quickly. This help included food, clothes, medicine and other day-to-day requirements.

7.5 Awareness of Coastal Hazards

Almost all those who took part in focus group discussions shared the view that lack of prior experience of tsunamis or other coastal hazards was one of the major causes of high casualties. There was not only ignorance among people living in the area but also among GN officers attached to various organisations. For example, a participant of the focus group discussion pointed out that when the Matara police station requested assistance from the police station in Galle about 15 minutes before it was hit by the tsunami, the police forces in Galle had not taken any measures to warn people in the Galle area. Moreover, many people were killed by the tsunami when running to the beach to watch the setback of the sea waves, a phenomenon they had never seen before.

It was understood through people's comments that much of the damage to physical assets and human lives could have been prevented if people had known more. It seems necessary to raise awareness of the causes of the tsunami and the way it operates in different situations. Lack of knowledge also created other vulnerabilities in coastal locations. People in those areas – particularly women and children – are now terrified of the possibility of more tsunamis. It has also been revealed that inaccurate messages and rumours about the recurrence of the tsunami have disturbed and damaged community life. Therefore, knowledge-building about the tsunami will reduce the damage from future tsunamis and help to establish normality in everyday life.

7.6 Financial Help from the Government and NGOs

It came to light that various types of assistance were available for the affected families from governmental and non-governmental organisations in the affected areas. Compensation was twofold: for living allowances and for housing construction. Under living allowances each affected family was granted 5,000 rupees, and many families have received four such instalments. An additional allowance of 2,500 rupees was granted for the purchase of kitchen utensils.

As for housing damage, the government approved 250,000 rupees for full damage and 100,000 rupees for partial damage. This compensation was approved only for families living outside the 100m buffer zone. At the time of this study, almost all such families had received half of their compensation and were awaiting the rest. However, some families were critical of the fact that the same compensation was paid to all families irrespective of damage.

Arrangements are presently under way to provide housing for families living in the buffer zone. Many were resettled in the same place or elsewhere, in temporary houses provided by local NGOs and foreign organisations. The construction of permanent houses was mainly carried out by the government in collaboration with donor agencies. Presently, only few such housing clusters have been completed and people resettled, and there have been complaints about unfairness. As one woman pointed out in an in-depth interview: "I lost a permanent house along with valuables. However, my neighbour who lost her temporary house will get a house similar to what is allotted to me." It was revealed that in addition to direct financial assistance, various local and foreign organisations had donated equipment and utensils for some families. For instance, one German organisation was known to have donated fishing boats and fishing gear to a group of selected families in Pettigalawaththa. There was no visible coordination in distributing such assistance among needy families.

7.7 Impact of Assistance on Coping Capacities

The role of governmental and non-governmental organisations in improving the living conditions of the affected families has been significant. However, through the FGDs it emerged that there were inadequacies in the distribution of relief aid, especially by government officials. Dry rations distributed to the affected families, such as rice, flour and dhal, were often not suitable for consumption, As most of the families reported. Also, such relief assistance was granted mainly to families living in the camps and transitory houses, others who lived elsewhere, with friends or relatives, were neglected.

The socio-economic background of affected families was an important factor in determining their ability to cope with the damage caused by the tsunami. Some people pointed out that relief assistance was granted to some non-affected families due to favouritism by GN officers in certain divisions. Some said officers had not asked recipients about their requirements and preferences while resettling them. Therefore, some families were resettled in far-off places and were unable to pick up their previous work. Also, in providing compensation or new houses, no attention was paid to the value of real losses, and this particularly frustrated families that had been better off. As they pointed out, the living conditions of poor families were uplifted while the conditions of previously well-off families worsened as a result of the relief work.

7.8 Access to Information

A large number of families in temporary shelters or transit houses have only limited access to information through TV and radio, due to the unavailability of electricity; and they cannot afford to buy newspapers. As a result they are not being updated about current development programmes for tsunami victims.

Some FGDs revealed that there were no proper channels of information from government institutions working with recovery programmes. Also, GN officers had not taken sufficient steps to inform families about existing development programmes and the benefits available to them. They further pointed out that some of the available relief assistance was not received because people did not know about it. For example, some families in the Mahamodara GN division did not get the help offered to their children by UNICEF because they had not been made aware of the programme's benefits.

The coping capacities of some of the affected families diminished considerably while they lived in a state of uncertainty about their future. One such affected person said they were not informed of the whereabouts of their resettlement. Living in a state of fear and uncertainty had had a seriously negative impact on their whole recovery process.

7.9 Powerlessness and Marginalisation

The powerlessness and marginalisation of some communities in affected areas greatly reduced their coping capacities. Such situations were mostly reported among families living in the 100m buffer zone. Many were economically and socially deprived, and unable to mobilise themselves to get help from government. At one point some of these groups organised a protest in front of the divisional secretariat, in order to get permanent accommodation, but their attempts were not successful.

One group of families said that their land had been taken from them for the reconstruction of Galle harbour, and compensation had not been granted. They were forced to build houses in the 100m buffer zone as a result, and are now in desperate circumstances. Some participants in FGDs said there had also been mismanagement and corruption in the distribution of relief assistance. Some pressure groups with power and bargaining capacity were able to get the large share of assistance, whereas the voices of poor families living in the buffer zone as squatters were not heard at all.

7.9.1 100m Buffer Zone

The government's decision to implement the 100m buffer zone had various negative consequences for the poor and marginalised families. These families were not granted compensation for housing destruction as they were expected to be settled somewhere else. As a result of delays in being provided with permanent settlements, many opted to live either in camps or transit houses provided by NGOs in the area. In addition to the loss of living and properties, they had to face uncertainty over when and where they would get resettled, and this contributed to their further marginalisation.

Some FGDs revealed that people had not known about the government decision concerning the 100m buffer zone. They were also given different information by different sources, which further aggravated the situation. According to them, even GN officers were not properly informed of the rules in order to give them a clear picture. Furthermore, inaccurate information spread by the government, with regard to the rule about acquiring lands within the 100m zone, had increased uncertainty. People in the 100 meter zone shared the view that if there had been no buffer zone, many of them could have constructed permanent houses with the assistance of foreign donors.

7.9.2 Relocation of Housing

FGDs also revealed differences in people's expectations of the resettlement process. The Muslim communities who used to live as clusters wished to be resettled with the same families they lived with previously, and wanted to live close to mosques. Fishermen's families, however, wanted to settle close to the sea for easy access to fishing boats and fishing gear. Likewise, families involved in informal sector work such as petty trade and self-employment wanted to be resettled within the city, where their business opportunities were mainly located.

In addition, families living in transit houses faced a variety of problems. Temporary shelters provided by the NGOs were found to be too small for large families of five to seven members. The shelters were about 200 sq ft in size, made of wooden planks and thatched with iron sheets, and people said they were not adequate for children's education, women's privacy and for healthy living in general.

Further interviews revealed that some families who had already found permanent housing on resettlement schemes were also facing problems. People spoke of being looked down upon and resented by settlers in the surrounding areas. This could have been jealousy over their having been given new houses. On occasion conflicts had also arisen when families socio-economically not compatible with each other were housed side by side.

7.9.3 Early-Warning System

FGDs with affected families also revealed that, because of the common fear of a recurrence of the tsunami, an early-warning system was a requirement of the recovery process. Some people believed that there would not have been such severe damage to their communities had an early-warning mechanism been in operation. It was useful to find out the views of affected people on mechanisms that would best suit their requirements. Many people in temporary shelters and transit houses thought mass communication networks such as radio and TV sets would not suit this purpose as many of them have no access to such facilities due to the lack of electricity. Therefore the following mechanisms were considered more appropriate:

- Conveying messages through public address systems currently available at Buddhist and Hindu temples, mosques and churches;
- Installation of siren systems on higher ground in the affected areas;
- Installation of a mechanism to measure the movements of sea waves through which warning could be conveyed to people at risk and in emergency situations.

The common view was that the police or armed forces would not be suitable for this system as they were busy enough with other work. A specific task force would be needed for the job, provided with sufficient training and responsibilities. It also emerged that people considered it vital to implement special training programmes for those living in coastal locations, dealing with coastal hazards, evacuation routes and other pre- and post-hazard arrangements.

8 Reducing Vulnerability: Intervention Tools

by J. Birkmann and N. Fernando

8.1 Introduction

The discussion on intervention tools and measures to reduce vulnerability in Sri Lanka is highly political and often controversial. Major topics within this debate include or included (during the time of the study) the 'buffer zone', restrictions on reconstruction, resettlement, early warning, compensation and financial support mechanisms. In the following sections, we will briefly discuss three specific intervention tools: the 100m buffer zone; the resettlement issue; and the installation of an early warning system in the context of indicators to measure and reduce vulnerability.

8.2 100m Buffer 'Risk Zone'

It is evident that in Batticaloa and Galle the tsunami wave went much further inland than just 100m from the shore, as shown in a study on Galle (Herath 2005). The comparison between the inundated area and the 100m, 200m and 300m lines from the shore (see Figure 7) clearly shows that the water from the tsunami wave went much further inland. Although it is clear that the run-off area of the tsunami wave extends even up to the 200m line and, in some areas, to the 300m line, it is important to take into account the different damage patterns within the inundation area captured in the household survey. The household survey and the post-tsunami census show that the likelihood of people being killed, or of a house being totally destroyed, is much higher in the 100m zone than in the areas further inland. Using a 99 times random-choice analysis to derive an equal number of households inside and outside the 100m zone (but still close to the sea) for the different damage categories, the likelihood of a house being totally destroyed was found to be nearly three times higher inside the 100m zone than outside. The actual inundation covered nearly all of the selected GN divisions, especially Magalle, Pettigalawaththa and Katugoda. A buffer zone is an important element in vulnerability and risk reduction, since recent urban development has not taken into account the risk of tsunamis and the problem of restricting development close to the sensitive coastal environment. However, it is also obvious that a superposed 100m line is not an appropriate tool. Therefore, more appropriate and precise criteria for defining the high-risk zone are needed. The *Coastal Conservation Act,* which was not applied sufficiently rigorously, would at least offer some more criteria to consider within this discussion (Coast Conservation Department of the Ministry of Fisheries and Aquatic Resources 2004).

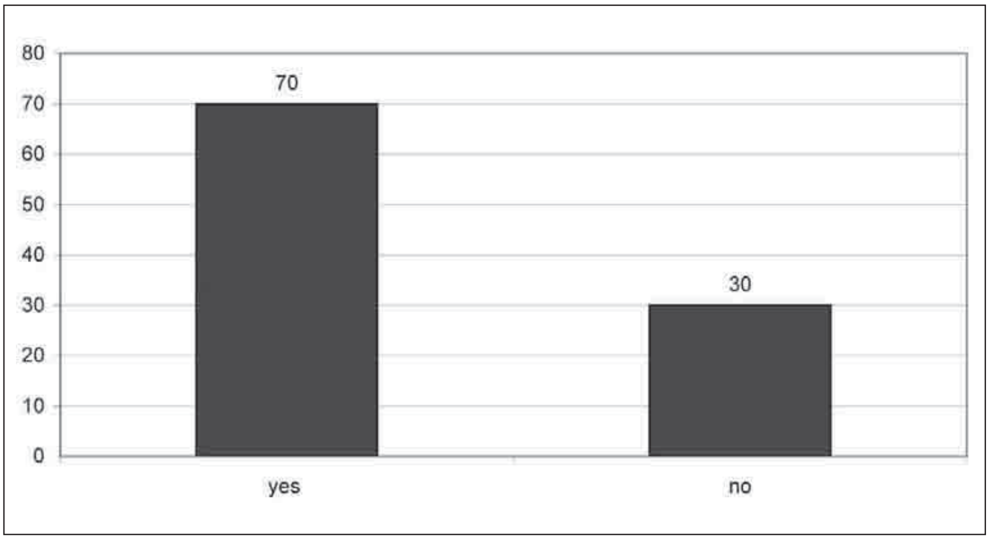
The results of the focus-group discussions (see Chapter 7) underline that it is essential to promote a more transparent procedure for defining an adequate buffer zone for Galle and other coastal communities in Sri Lanka. Additionally, the specific needs of different groups in terms of their access to the sea (fishermen) or to the city centre (small scale business) should be taken into account.

Although from a politician's and planner's point of view it might be easier to permit reconstruction everywhere again (because there would be no complaints), an increase in the vulnerability of coastal communities would again be implied. Step-by-step amendment of the buffer zone, especially the reduction from 100m to 50m or to 20m, without proper building regulations for structural qualities, is problematic as well. Local and national stakeholders should find an appropriate compromise for a buffer zone that acknowledges the damage patterns based on the devastation caused by the tsunami and also the needs of people whose livelihoods depend on close access to the sea. In this context, it is important to implement a more transparent and reliable policy which ensures that, in making their investment, individuals are all on an equal footing, and that the buffer zone does not only apply to some of the households in the 100m zone. Rules concerning the buffer zone, rebuilding and resettlement have been changed often.

8.3 Resettlement

The questionnaire survey asked interviewees whether they would agree to move to a safer place and vacate their present coastal location. Interestingly, six months after the tsunami more than two-thirds of respondents in Galle (nearly 70 percent) said yes, and only one-third said they would not (see Figure 35).

Figure 35: Willingness to resettle in a safer location inland: Galle



Source: J. Birkmann and N. Fernando

When examining the relationship between socio-economic variables and the resettlement question, interesting patterns emerge (see also Chapter 10). For example, in Galle a significant proportion of squatters, who lived within the 100m buffer zone before the tsunami, agreed to move to a safer place (75.4 percent), in contrast to 67 percent of those households who owned their land. This shows willingness by squatters to resettle, not only to protect their lives and valuables from coastal hazards but to move away from a vulnerable situation of chronic poverty by gaining a legally accepted, permanent place to live. Similar differences were found in the data for Batticaloa. However, the number of encroachers in the 100m zone in Batticaloa is not as significant as in Galle, representing just over 17 percent of encroachers (based on our questionnaire survey in selected coastal locations in Galle). However, the possibility that the tsunami disaster could trigger poverty reduction and social change – as discussed in other contexts, for example in a recent study by the university of Bayreuth, GTZ and DKKV (Schmidt et al. 2005) – does not apply here. Encroacher households do not receive any governmental support for relocation – at the time of the research and field work – because officials argue that this would promote future encroachment and illegal settlement.

8.4 Installing an Early-Warning System

The questionnaire results showed that only a negligible proportion of respondents knew about tsunamis and coastal hazards. Thus, their knowledge in this regard should be strengthened, although nearly all respondents have now experienced the devastating nature of high tsunamis waves. None of the interviewed respondents was aware that their residence or village could be hit by a tsunami prior to 26 December 2004. After the disaster, a significant proportion of respondents stated that an early-warning system should be installed in their area as a matter of necessity. Also, the focus-group discussions (see Chapter 7) revealed that people were looking for a reliable early-warning system, not one that gave false alarms and weakened confidence in the system .

8.5 Challenges and Limitations

This study shows that measuring vulnerability and developing indicators to visualise various aspects of vulnerability are important for the promotion of a profound understanding of communities at risk. The indicators allow identification of the most vulnerable groups which should be considered in future reconstruction, in development plans and in early-warning strategies (e.g. with regard to evacuation). The selected indicators underlined major differences in terms of the revealed vulnerability of women, the young and the elderly. In addition to this, the measurement of the difficulties in recovering (index of time households need to recover from housing damage) reveals an opportunity to assess the vulnerability of people after a disaster. Although the index focuses primarily on household income (which is also strongly linked to household structure) and the degree of actual damage to the house, it also reveals major differences between the two cities examined within the study, Galle and Batticaloa.

Moreover, the ability to replace actual losses and to recover from deprivation does not depend solely on the individual income of a household head. Exposure, the actual level of damage and the structure of the household, particularly, the size of the household, the number of breadwinners and the job profile, also have an important influence on the outcome of the recovery index (see Chapters 5 and 6).

Yet the questionnaire-based survey clearly underlines that there are important limitations with regard to the measurement of vulnerability, such as the problem of calculating incomes after the tsunami, and the difficulty of assessing support received by families over the medium and long terms. Often, extraordinary circumstances, such as the contribution of external aid, dominate and influence the situation after a mega-disaster. Even though some indicators are interesting and meaningful in theory – such as the number of people who received financial aid from international or governmental agencies – it is difficult to interpret whether this support is appropriate, and whether it really produces incentives for the people affected to generate their own resources for overcoming the negative impacts of such a natural hazard. In some cases we observed that household members did not continue with their previous work because they were receiving monthly compensation for their loss of income anyway. These aspects make an easy interpretation of the results nearly impossible.

9 Measuring Revealed Vulnerability Using Census Data

by D. Paranagama

The most recent census of population and housing in Sri Lanka was carried out in 2001. However, it was incomplete because some districts in the Northern and Eastern provinces were excluded due to their inaccessibility as a result of the military conflict. So the census did not cover some of the districts hit by the 2004 tsunami. And data collected by various individuals and organisations after the tsunami was found to be of questionable coverage, reliability and comparability. At the same time, families were unable to prove their ownership of tsunami-damaged property, or even that they lived in the tsunami-affected area, because they had no legal documents. And some housing units were completely washed away, leaving no trace. The only document which could trace the location of housing units was the 'F1 sheet', the form listing housing units, non-housing units and living quarters other than those prepared for census-taking by the Department of Census and Statistics. However, the F1 sheet was not a legal document. In consequence the government instructed the Director-General of the Department of Census and Statistics to carry out a census of the tsunami-affected areas using the F1 sheet as the basic document. This chapter gives an overview of vulnerability indicators generated through available census data and, in particular, the post-tsunami census. We also tried to develop similar indicators to those already tested in the questionnaire-based household survey, by focusing on whether and to what extent it would be feasible to generate vulnerability information with regard to gender, age, income, land title, etc, out of the present census data for the cities of Galle and Batticaloa.

According to the post-tsunami census 577,864 persons were affected, and out of that number 31,355 were killed and 546,509 displaced in Sri Lanka. This means that 5.5 percent of the total population in the 13 districts were affected, deaths accounting for 0.3 percent and displaced population 5.2 percent. In other words, three people per thousand of the population died within a few hours.

The post-tsunami census shows that at the sub-national level the disaster did not uniformly affect the 13 districts. The proportion of population affected in Trincomalee, Mulativu and Ampara was comparatively very high, as one in five of the population in the three districts was affected. The proportion of deaths was high in Mulativu (2.5 percent) and Ampara (1.8 percent). The number of people affected in Ampara and Galle was high, varying between 110,000 and 126,000. The number of deaths was high in Ampara (10,435), Hambantota (4,500) and Galle (4,214). The factors which contributed to variation in the levels of damage included the height and force of the tsunami waves, proximity of the population to the sea, physical features of the land and the density of population, as well as the quality and structure of the built environment in the coastal belt.

9.1 Galle and Batticaloa Post-Tsunami Census

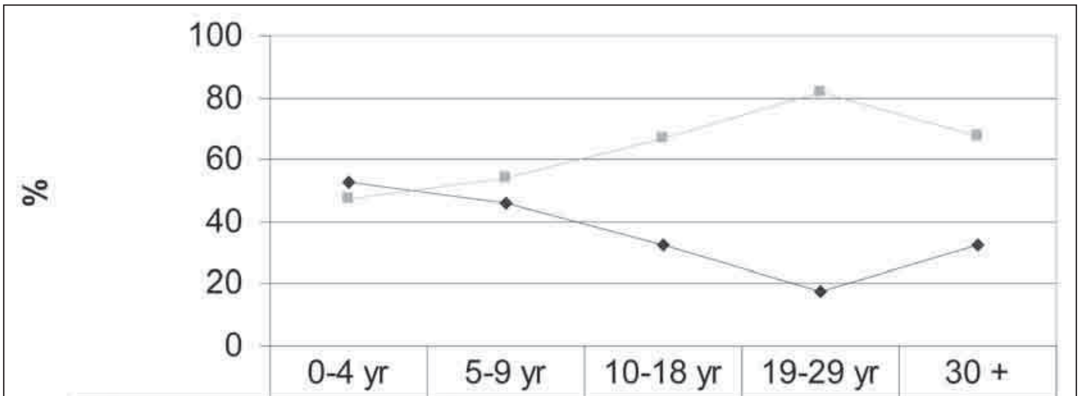
9.1.1 Displaced Population and Deaths

In the two study districts of Galle and Batticaloa the post-tsunami census shows that the numbers of people displaced and killed in Galle (121,934 and 4,214 respectively) were much higher than in Batticaloa (57,049 and 2,840 respectively); but the ratio of deaths to displaced population was higher in Batticaloa (0.0498) than in Galle (0.0346). One explanation might be that the size of the coastal belt population was very high in Galle compared to Batticaloa. At the same time, population density in Galle (613 per sq km) district is also higher than in Batticaloa (186 per sq km).

9.1.2 Age and Gender of People Died in the Tsunami

The age breakdown of those who died or went missing in Batticaloa, given below, clearly shows that females and children were at higher risk and the most vulnerable group. Out of all those who died or went missing in Batticaloa 29 percent belonged to the age group 0-9 years (see Figure 36).

Figure 36: Age of dead and missing in Batticaloa

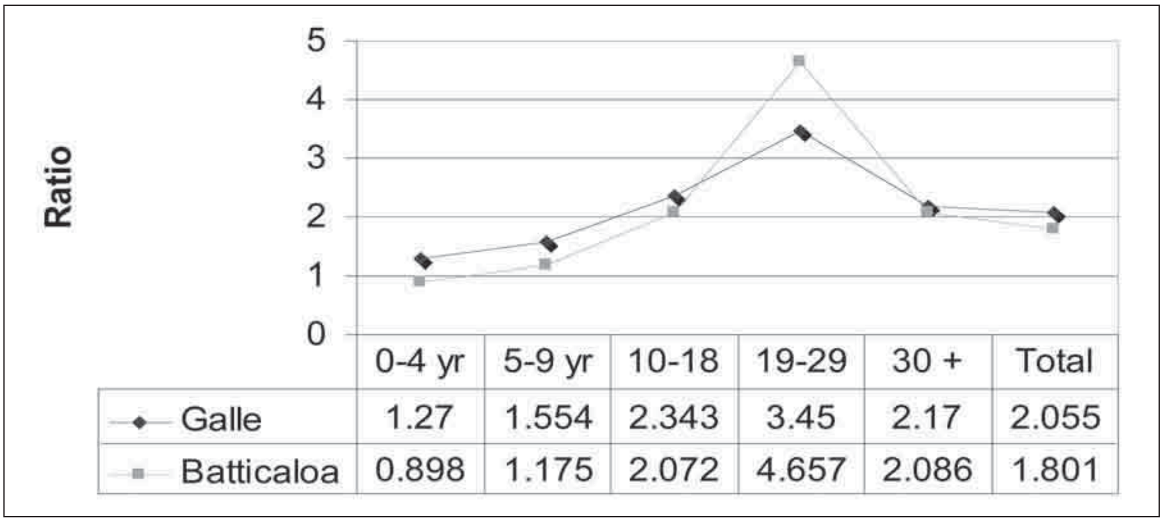


	0-4 yr	5-9 yr	10-18 yr	19-29 yr	30 +
Male	52.7	46	32.4	17.6	32.4
Female	47.3	54	67.2	81.9	67.6

Source: Dharmadasa, based on data of the post-tsunami census, Dep. for Census and Statistics

The ratio of female to male deaths in Galle and Batticaloa, given in Figure 37, indicates that females in the age group 19-29 years were at a higher risk.

Figure 37: Ratio of female to male tsunami-related deaths (by age): Galle and Batticaloa



Source: Dharmadasa, based on data of the Post-Tsunami census, Dep. for Census and Statistics

These figures show that the specific female age group 19-29 years was at a higher mortality risk in Batticaloa than in Galle.

The post-tsunami census does not allow for an in-depth analysis of the mortality risk of elderly people, since most data is not available for these age groups (only for 30 years plus). With regard to the deaths of disabled people, however, a more detailed statistic was available.

9.1.3 Deaths of Disabled

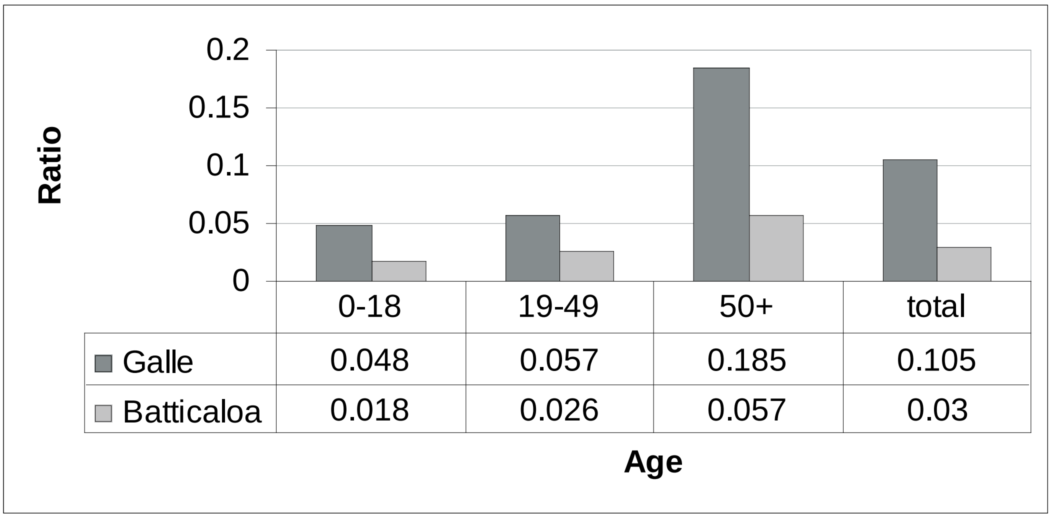
Disability was a vulnerability factor. Table 6 and Figure 38 give the number of deaths of disabled and non-disabled people and then ratio of deaths of disabled to non-disabled for Galle and Batticaloa. It is clear that vulnerability was high among elders aged 50 plus. The incidence of death among disabled people was higher in Galle than in Batticaloa.

Table 6: Number of disabled and non-disabled people killed and ratio by age: Galle and Batticaloa

	Galle deaths			**Batticaloa deaths**		
Age yrs	Disabled	Non-disabled	Ratio of deaths of disabled to non-disabled	Disabled	Non-disabled	Ratio of deaths of disabled to non-disabled
0-18	21	434	0.048	13	712	0.018
19-49	28	487	0.057	14	543	0.026
50+	112	606	0.185	21	366	0.057
Total	161	1527	0.105	48	1621	0.030

Source: Post-Tsunami census, Dep. for Census and Statistics

Figure 38: Ratio of deaths, disabled to non-disabled: Galle and Batticaloa



Source: Dharmadasa, based on data of the post-tsunami census, Dep. for Census and Statistics

Table 7: Percentage of deaths by age and gender: Galle and Batticaloa

	Galle			Batticaloa		
Age	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
0-4	17.2	10.6	12.7	22.0	10.9	14.9
5-9	9.6	7.3	8.0	18.3	11.9	14.2
10-18	6.0	6.8	6.6	13.3	15.3	14.6
19-29	6.9	11.5	10.0	5.6	14.5	11.3
30 & more	60.4	63.8	62.7	40.9	47.3	45.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
N	583	1198	1781	624	1124	1748

Source: Post-tsunami census, Dep. for Census and Statistics

Although Table 7, above, indicates higher fatalities among women, the relative distribution shows that young male children were much more at risk than the relative amount of the same age group for females. However, this statistic lacks a more precise differentiation of the age groups above 30 years.

9.1.4 Deaths by Occupation

An idea of the vulnerability by occupation can be gained from Table 8. The number of deaths among males was high in the categories of 'fishing', 'trade', 'other services', 'other' and 'government sector' in Galle. In Batticaloa 'fishing', 'trade', 'other' and 'government sector' were also prominent. The coir industry (using coconut fibre for matting, ropemaking, etc) in Galle was primarily a female occupation, and their number of deaths was high. Female deaths were also high in Galle in the occupations of 'other manufacturing', 'other' and 'government sector'. In Batticaloa female deaths in the government sector were low.

Table 8: Number of deaths by gender and occupation

Deaths by Occupation	Percentage		Ratio of Female to male deaths	
	Galle	Batticaloa	Galle	Batticaloa
Agriculture	1.9	2.5	0.60	1.00
Fishing	9.7	53.2	0.08	0.08
Coir industry	11.7	0.0	47.00	
Limestone	1.5	0.0	0.20	
Other manufcturing	7.0	3.0	4.80	0.83
Trade	21.8	6.0	0.73	1.00
Tourism	2.2	0.0	0.29	
Other services	14.8	5.0	0.39	0.70
Other	16.5	23.4	0.89	0.64
Govt sector	12.9	7.0	1.94	0.50
Total	100.0	100.0	0.96	0.38

Source: Post-Tsunami Census, Dep. for Census and Statistics

9.1.5 Highest Height Submerged

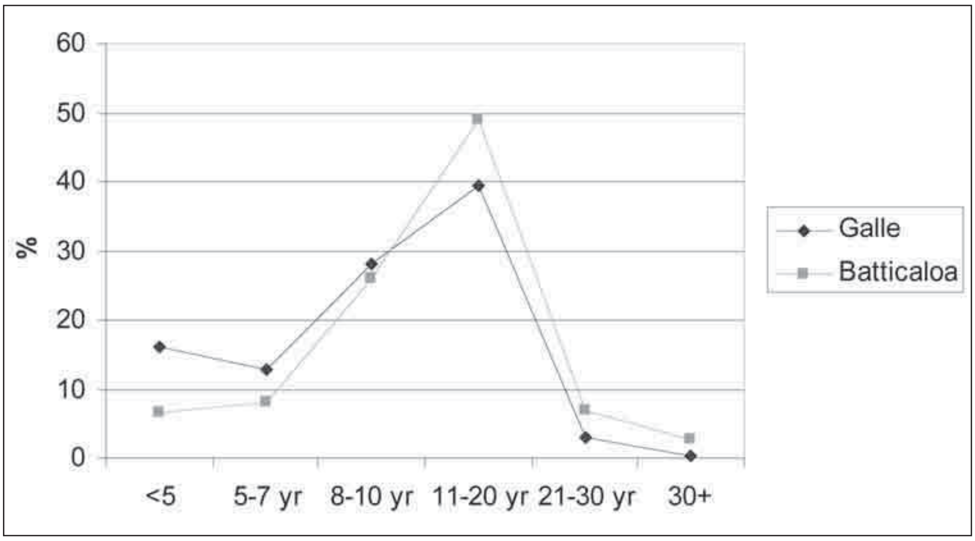
Regarding the percentage of housing units damages due to a specific height of submerge Table 9 shows that in Batticaloa and Galle most housing units damaged were to be found in a range of 11-20 feet submerge height. However, major differences between Batticaloa and Galle can be seen when comparing lower submerge heights. In Batticaloa for example a high percentage (around 58%) of housing units were located in submerge heights of 0-10 feet. In contrast this is not the case in Galle, where the same categories account solely around 40% (see Table 9). The table shows that in Batticaloa substaintial damage was caused by a wider range of submerge heights whereas in Galle major damages were caused by submerge heights in the middle of the spectrum (8-10 and 11-20 feet). From own observations, the damage in Galle was more concentrated in a narrow margin, whereas in Batticaloa it was spread more widely.

Table 9: Percentage of housing units damaged (by highest height submerged, in feet): Galle and Batticaloa

	Highest height submerged (feet)							
	Less than 5	6-7	8-10	11-20	21-30	30+	Ns	Housing Units
Batticaloa	16.1	12.7	28.0	39.4	3.0	0.4	0.4	5487
Galle	6.7	8.0	26.1	49.0	7.0	2.8	0.4	4885

Source: Post-Tsunami Census, Dep. for Census and Statistics

Figure 39: Percentage of housing units damaged (by highest height submerged, in feet): Galle and Batticaloa



Source: Dharmadasa, based on post-tsunami census, Dep. for Census and Statistics

9.1.6 Proximity to the Sea (Exposure)

In comparing data it should be noted that the buffer zone demarcated for Galle was 100m and for Batticaloa it was 200m. Proximity to the sea was one of the factors that caused high damage to housing units. In both districts the proportion of damage (unusable) was high in the buffer zone. In Batticaloa 97 percent of housing units in the buffer zone were damaged (unusable) compared with 63 percent in Galle (see Table 10 and Figures 40 and 41). This pattern can be noticed clearly in Galle Four Gravets (Table 11 and Figure 44) where data is available in detail. Damage was high closer to the sea and it reduced gradually moving inland.

Table 10: No. and percentage of housing units damaged (by distance from beach): Batticaloa/Galle

Batticaloa						
	Damaged			**Percentage damaged**		
Distance from sea	**Unusable**	**Usable**	**Total**	**Unusable %**	**Usable %**	**Total %**
<200m	1,429	40	1,469	97.3	2.7	100.0
200m+	5,898	6,287	12,185	48.4	51.6	100.0
Batticaloa	7,327	6,327	13,654	53.7	46.3	100.0

Galle						
	Damaged			**Percentage damaged**		
Distance from sea	**Unusable**	**Usable**	**Total**	**Unusable %**	**Usable %**	**Total %**
<100	3,073	1,811	4,884	62.9	37.1	100.0
100+	2,826	4,654	7,480	37.8	62.2	100.0
Galle	5,899	6,465	12,364	47.7	52.3	100.0

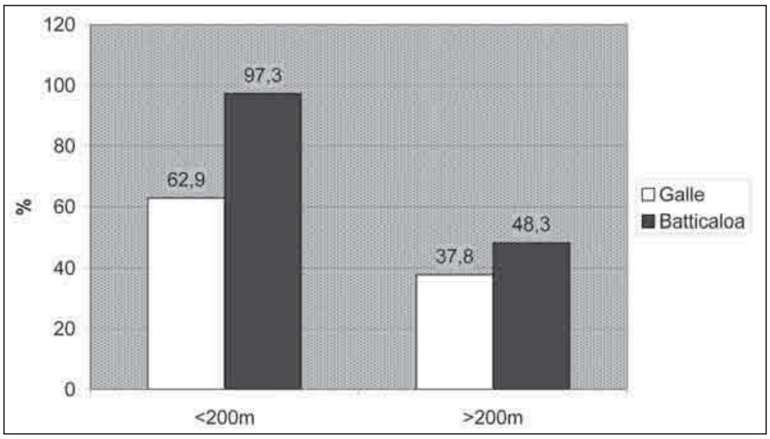
Source: Post-Tsunami Census, Dep. for Census and Statistics

Table 11: Number and percentage of housing units damaged (by distance from beach): Galle Four Gravets

Galle	Less than 100m	101-200m	201-300m	301 or more	Total damaged
Number	934	467	134	52	1587
Percent	58.85	29.43	8.44	3.28	100.00

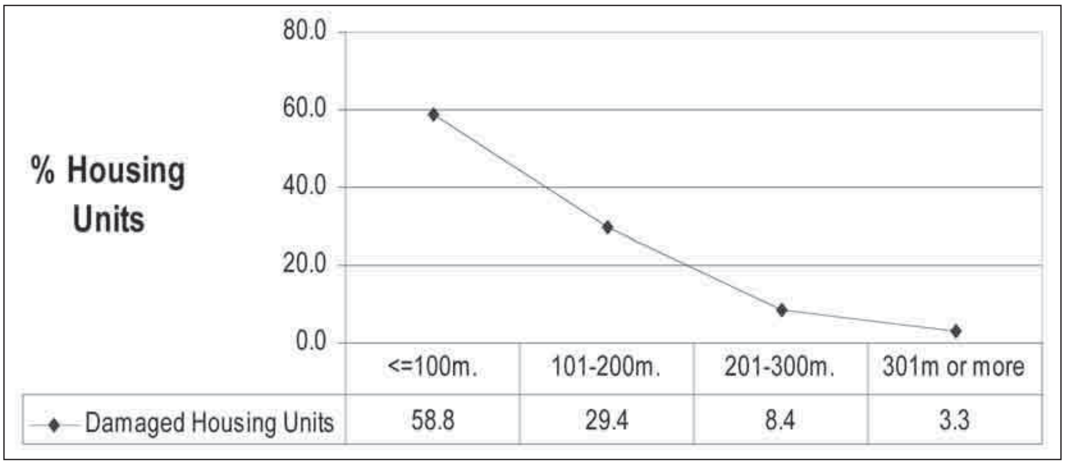
Source: Post-Tsunami Census, Dep. for Census and Statistics

Figure 40: Percentage of housing units damaged (unusable) for Batticaloa and Galle



Source: Post-Tsunami Census, Dep. for Census and Statistics

Figure 41: Percentage of housing units damaged (unusable) (by distance from sea): Galle Four Gravets



Source: Post-Tsunami Census, Dep. for Census and Statistics

9.1.7 Permanent and Temporary Housing Units

Housing units were considered permanent if the roof, walls and floor were constructed with permanent material. The roof was considered permanent if made from tiles, asbestos, etc, and temporary if made from cadjan (coconut leaves), tin sheets, etc. Walls were considered permanent if made from bricks, cement blocks, etc, and temporary if made from mud, wood, tin sheets, etc. Any combination of materials other than 'permanent' was considered 'temporary' in the following tables.

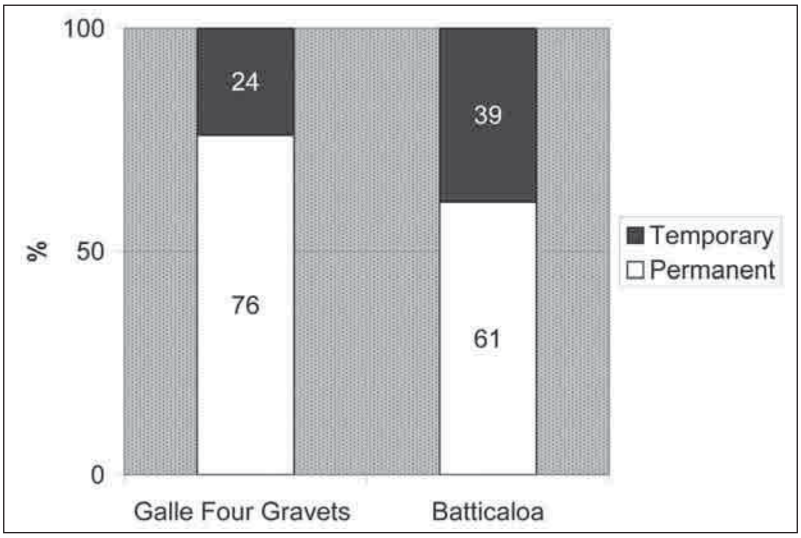
The percentage distribution of housing units damaged by material used (permanent and temporary) is given in Table 12 and Figure 42, below. Temporary housing units are considered more vulnerable than permanent. In both districts there were more permanent housing units than temporary ones, and so damage done to permanent houses was high.

Table 12: Number and percentage of housing units damaged (by type of house) : Galle Four Gravets and Batticaloa

	Permanent	Temporary	Total	Permanent %	Temporary %	Total %
Galle						
Four Gravets	1,207	381	1,588	76.0	24.0	100.0
Batticaloa	8,447	5,410	13,857	61.0	39.0	100.0

Source: Post-Tsunami Census, Dep. for Census and Statistics

Figure 42: Percentage of housing units damaged (by type): Galle Four Gravets and Batticaloa



Source: Post-Tsunami census, Dep. for Census and Statistics

This data did not allow for the precise distinction in houses' location in terms of their exposure.

9.1.8 Ownership of Houses

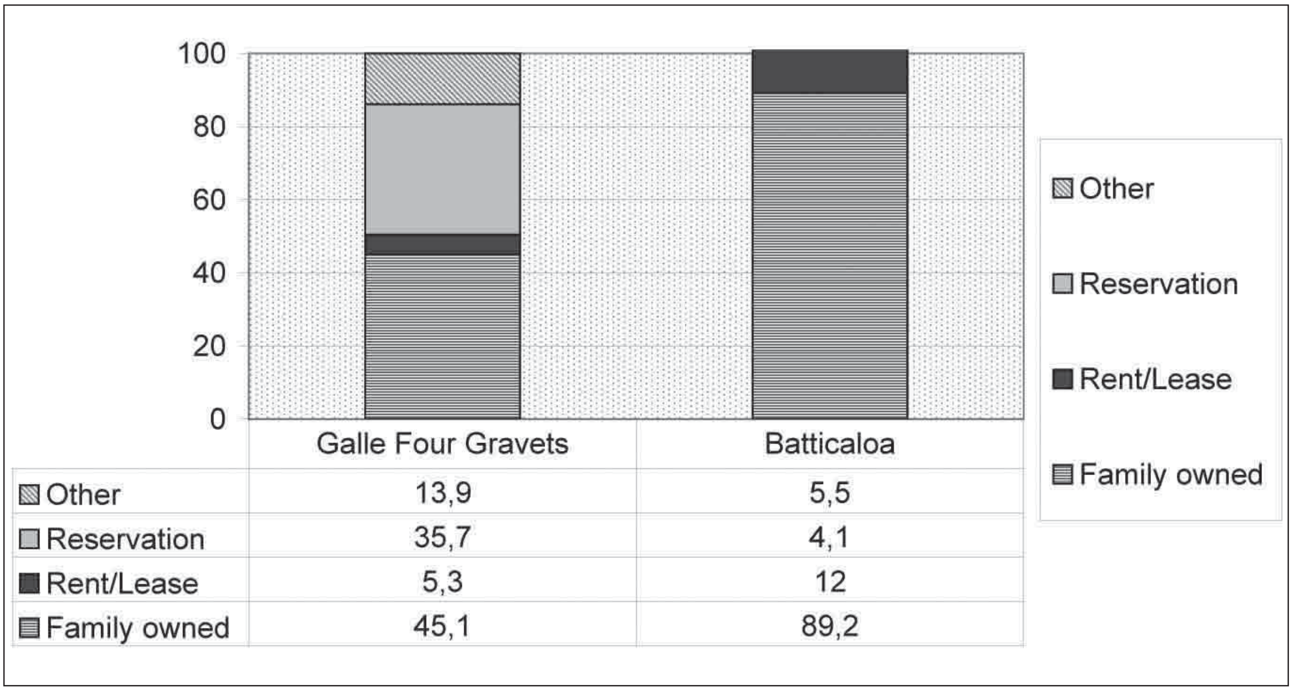
Ownership of housing units (see Table 13 and Figure 43) differs considerably. Due to high population density in Galle pressure on land is high, and the tendency to encroach on government land/ reservations is also relatively high (category "reservation"). Interestingly, family owned housing units in Batticaloa were twice as high as those in Galle.

Table 13: Percentage of damaged housing units (by ownership): Galle Four Gravets and Batticaloa

	Ownership of Land					
	Family owned	Rent/ lease	Reservation	Other	Total	N
Galle Four Gravets	45.1	5.3	35.7	13.9	100.0	1,587
Batticaloa	89.2	1.2	4.1	5.5	100.0	13,871

Source: Post-Tsunami Census, Dep. for Census and Statistics

Figure 43: Percentage of housing units damaged (by ownership): Galle Four Gravets and Batticaloa



Source: Drahmadasa, Post-Tsunami Census, Dep. for Census and Statistics

The analysis reveals that major difficulties in access to land (resulting in squatters) are more prominent in Galle than Batticaloa. This means that the census data underlines the necessity, identified in the household survey, of reconstruction strategies taking into account the problem of lack of access to land (see Chapter 5).

9.1.9 Housing Units by Income

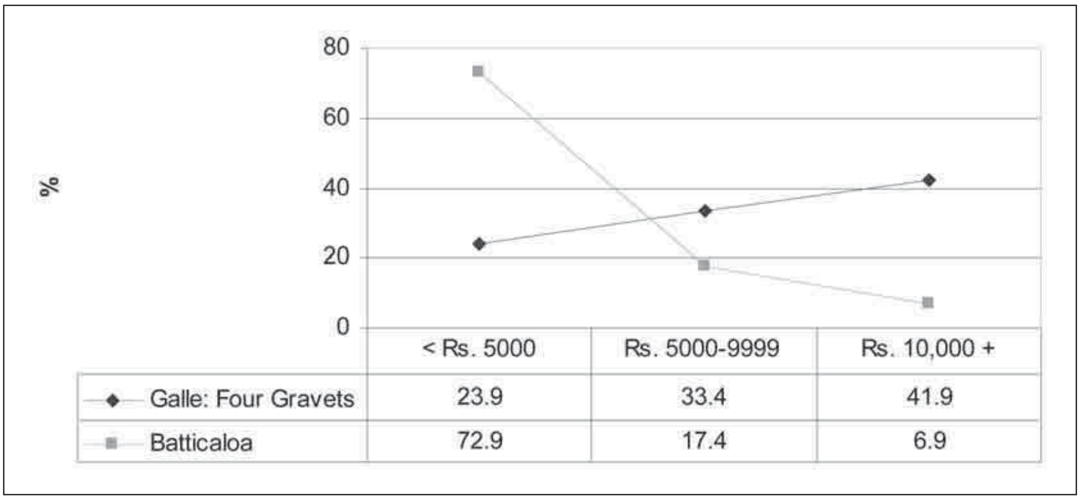
Distribution of households by monthly income is given in Table 14 and Figure 44. If the conversion rate is taken as 100 rupees as equivalent to 1 US Dollar, the monthly incomes of nearly three households in four (73 percent) were below US$50 in Batticaloa, compared to one household in four (24 percent) in Galle. Distribution of households by income shows a negative association in Batticaloa, while there is a positive association in Galle.

Table 14: Percentage distribution of damaged housing units (by monthly income): Galle Four Gravets and Batticaloa

Housing Units in Tsunami-affected GN Division by Monthly Income						
	< Rs. 5,000	**5000-9999**	**10,000 +**	**Not reported**	**Total**	**N**
Galle Four Gravets	23.9	33.4	41.9	0.8	100.0	1,570
Batticaloa	72.9	17.4	6.9	2.8	100.0	5,487

Source: Post-Tsunami Census, Dep. for Census and Statistics

Figure 44: Percentage distribution of damaged households (by monthly income): Galle Four Gravets and Batticaloa



Source: Post-Tsunami Census, Dep. for Census and Statistics

9.1.10 Economic Activity in Damaged Households

As the categories in Tables 15 and 16 show, a considerable proportion of the affected population both in Galle and in Batticaloa was engaged in 'fisheries-related activities', 'agriculture/livestock', 'other manufacturing industries' and 'trade'. As mentioned earlier in this chapter, a significant proportion of women in Galle were engaged in the coir industry. The number of affected people engaged in agricultural activities in Galle was very low, while more women were engaged in agriculture in Batticaloa. Thirty percent of the affected population in both Galle and Batticaloa were engaged in fishing or fisheries-related activities. After the tsunami most people could not continue their occupations. The ratio of those who did not function in their trades to those who did after the tsunami was higher in Batticaloa (8.3) than in Galle (3.3). This underlines the specific difficulties seen in the household survey with regard to potential time households need to recover in Batticaloa (see Chapter 5). The proportion of those engaged in agricultural activities in the tsunami-affected areas was lower in Galle (2.3 percent) than in Batticaloa (19.2 percent). In both districts the proportion of those engaged in fisheries-related activities was high (around 30 percent).

Table 15 : Population in affected GN divisions (by occupation): Galle Four Gravets

Galle: Four Gravets								
Population in affected GN Divisions by occupation								
GN Div.	Pop 15+ yr	Fishing	fisheries-related activities	Coir industry	Tourism	Govt. employ-ment	Other employ-ment	Unemployed /non-responded
Total	100.0	4.0	1.5	0.2	0.7	5.9	31.3	56.4

Source: Post-Tsunami Census, Dep. for Census and Statistics

Table 16: Percentage of number of employees in damaged households: Galle and Batticaloa

	Number of employees							
	Batticaloa				Galle			
	Male	Female	Total		Male	Female	Total	
Type of economic activity	%	%	No.	%	%	%	No.	%
Agriculture/livestock	14.7	27.1	87	19.2	2.5	1.9	41	2.3
Fisheries (for sale)	45.7	-	130	29.0	40.3	5.2	528	30.0
Other fisheries- related activities	1.4	-	4	0.9	4.6	2.7	71	4.0
Coir industry					4.7	35.3	242	13.7
Lime industry	1	1.2	5	1.1	4.7		59	3.3
Other manufacturing industries	11.2	21.8	68	15	13.1	22.2	278	15.8
Trade	18.5	27.7	99	21.9	13.8	18.7	268	15.2
Hotels/restaurants					4.3	4.8	78	4.4
Tourist hotels					0.6	1	13	0.7
Restaurants/guest houses/kabanas					0.4	0.6	8	0.5
Government service	0.3	-	1	0.2	0.1	0.2	2	0.1
Education service	0.3	0.6	2	0.4		1.2	6	0.3
Health service	-	0.6	1	0.2	0.4	0.2	6	0.3
Religious service	0.3	-	1	0.2				0.0
Other service	3.5	10.8	28	6.2	8.7	5.2	135	7.7
Other	2.1	9	21	4.6	0.6	0.6	11	0.6
NS	1	1.2	5	1.1	1.2	0.2	16	0.9
Total & Percentage	100	100	452	100	100	100	1762	100.0
N	286	166	452		1243	519	1762	
%	6.3	36.7	100.0		70.5	29.5	100.0	

Source: Post-Tsunami Census, Dep. for Census and Statistics

Overall, the post-Tsunami census can verify and upscale some of the vulnerability characteristics calculated and analysed within the household survey. However, though the census data allows a broader spatial analysis, data was often incomplete or aggregated (for example, in the differentiation of elderly people), and this implies that often only macro- and general trends could be assessed. Income data is especially vague, and data with regard to land title raises difficult questions – such as, what kind of data was examined in Batticaloa? It can be assumed that migration took place due to the military conflict, and so the numbers of households living on owned land are uncertain. This first analysis of the census data intended to juxtapose the results of the household survey with those figures that can be generated from the post-tsunami census.

10 Migration Due to the Tsunami in Galle

by U. Grote, S. Engel, B. Schraven

10.1 Introduction

According to the World Health Organization (WHO), the tsunami had a massive impact on people's lives in Sri Lanka: at least 1 million people were directly affected, and about 550,000 people were displaced. To gain a better understanding of the determinants of different social groups affected by the tsunami in Sri Lanka, a survey of 500 households has been conducted.

The design of appropriate prevention, assistance and resettlement policies requires improved information on the impact of the tsunami and why some vulnerable households choose to return to high-risk areas while others relocate to lower-risk areas. Therefore, one of the components of the project being investigated in a joint effort by UNU-EHS and ZEF aims at analyzing the determinants and effects of the migration decision at the household level.

10.2 Hypotheses

Four principal factors are hypothesized to affect the migration decision. They are proxied by several empirically measurable variables, some of which affect several of the principal factors simultaneously. In the latter case, the effect on the migration decision may be ambiguous. The principal factors and proxies are:

10.2.1 Perception of safety at place of origin

The general hypothesis related to the perception of safety is that the probability of migration increases with the level of insecurity at the place of the household's origin. The variables for the measurement of the perception of safety are:

- *Bad experiences with the sea prior to the tsunami;*
- *People being killed or heavily injured by the tsunami;*
- *Damage to the house caused by the tsunami.*

10.2.2 Income and standard of living

We expect that the probability of migration decreases with the standard of living and income at the place of origin and increases with the expected standard of living and income at the place of reception. The variables, which will be used as proxies for the expected standard of living and the expected income at a (possible) new place, are:

- *Characteristics of the household head (age, education, employment);*
- *Relatives at the place of reception.*

The variables of the expected standard of living and the expected income at the place of origin include:

- *Ownership of the land and house the household lived in before the tsunami;*
- *Possession of boats after the tsunami;*
- *Possession of motor vehicles after the tsunami; and*
- *Per capita income of the household before the tsunami.*

The variable "characteristics of the head of household" is one of those variables which appear for several times and may cause ambiguous effects on the migration decision.

10.2.3 Migration and information costs

It is hypothesized that a household is less likely to move the greater the associated migration and information costs. Costs can be financial, but also psychological. For example, it is expected that the longer a household has lived in an area, the stronger (and so the more emotional) are its links to this area and the expected effect for the migration decision is negative. The variables used for this proxy are:

- *Years lived in the area before the tsunami;*
- *Education of the household head;*
- *Relatives at the place of reception;*
- *Membership in one or more organizations;*
- *Access to information;*
- *Possession of motor vehicles after the tsunami;*
- *Per capita income of the household before the tsunami; and*
- *The receipt of support.*

The impact of a household's access to information can be positive or negative, depending on the type of information. That is, information may be encouraging or discouraging migration. For example, a higher level of education may lower information costs, but the effect is dependent on the kind of information. This is the same for the receipt of support: whereas the provision of construction materials is expected to discourage migration, other (particularly) financial compensation is expected to facilitate migration.

10.2.4 Household characteristics

Migration decisions are also affected by a household's general preference structure. The proxies used for this factor are:

- *Age of the household head:* Older households may be more risk averse. However, the migration decision requires weighing two types of risk: (i) the risk of future tsunamis, and the risks associated with moving to a new place and finding employment there. Older households may also be less open to new living environments. The overall effect of age from a theoretical perspective is ambiguous.
- *Sex of the household head:* We assume that female household heads are more risk averse than male ones. Again, the effect depends on how the two risks are evaluated by the household.

10.3 Descriptive analysis

About 35% or 178 households of the households interviewed lived in houses located within the 100 m zone from the mean sea level. The other close to 65% or 321 households were located further away from the sea. Since especially people living within the 100 m zone were negatively affected by the tsunami, the Government prohibits new construction within this 100 m zone (in some areas 200 m). In fact, half of the 143 houses which were heavily damaged by the tsunami were located within the 100 m zone, while 81% of the houses outside the 100 m zone just had minor or even no damages. Being asked about their opinion whether the establishment of a 100 m zone is appropriate, close to 80% of the respondents agreed that it is.

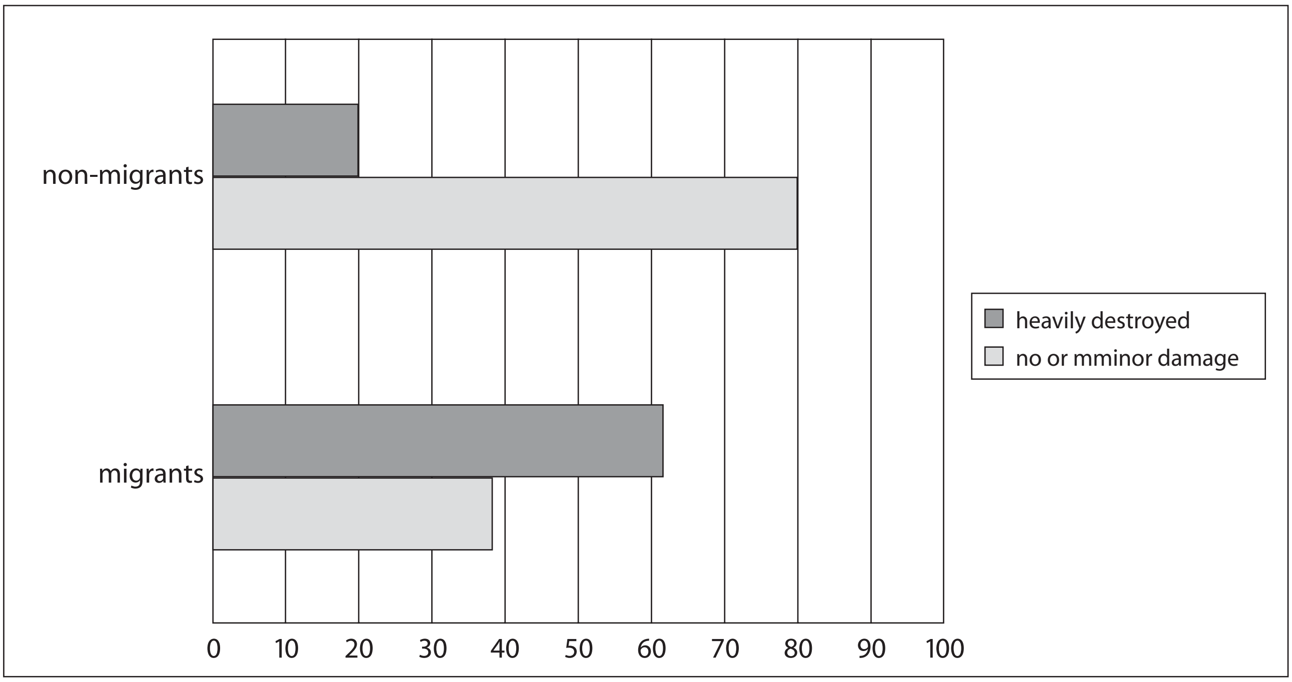
The data is further characterized as follows:

- A total of 216 households (43%) state that they are not willing to migrate; some households of this group currently live in temporary homes but have the firm intention to go back to their old places. We refer to them as the non-migrant households.
- 118 households (24%) intend to leave their old homes in the near future (nine of them already having done so), and thus we call them the migrant households.
- 166 households (33%) are still undecided about the decision of migration.

10.3.1 Perception of safety

The survey revealed that the migrant households are much more affected by a total destruction of their houses than non-migrant households (see figure 45): 62% of the migrants and just 19% of the non-migrants state, that their houses were destroyed so heavily that they are uninhabitable now. The differences between migrants and non-migrants concerning the rate of house destruction can easily be explained by the fact that 60% of the migrants and just 20% of the non-migrating households lived inside the 100 m zone before the tsunami; this indicates some support for the hypothesis that the more a house has been destroyed, the higher will be the probability of migration for the corresponding household.

Figure 45: House damages – non-migrant and migrant households



Source: U. Grote, S. Engel, B. Schraven

An interesting fact is that just 8% of the non-migrating households have had bad experiences with the sea before the tsunami (in forms of floods or seaquakes) compared to nearly 30% within the migration group. This also seems to support the idea that households which were negatively affected by the sea in the past, are more likely to migrate after the tsunami.

With respect to physical injuries, about 83% of the households indicated that they suffered no or only minor injuries, 8% of the respondents reported about serious injuries and hospitalization, while close to 9% of the respondents lost or still miss family members.

Interesting is that just 13 % of the non-migrant households have dead, missing or seriously injured members, whereas 26 % of the migrant households have members which were affected that way by the tsunami.

Concerning the question, whether a pre-warning system for tsunamis should be installed, the difference between the two groups is less significant: 85% of the non-migrant and 95% of the migrant households would approve the installment of such a system.

10.3.2 Income, standard of living, and changes in living conditions

Regarding the income before and after the tsunami event, almost 15% of the households indicated that they have now more income available compared with the situation before, while around 20% of the households have the same amount, and the remaining 65% have less income now available. Interestingly, most of the households with now higher income availability are also those who returned to the tsunami area, and only a few of them decided to move in the near future.

Concerning education and gender, the differences are also more or less marginal between the two groups: 30% of the non-migrant and 35% of the migrant household heads had no or a school education of up to six years, whereas the majority of the non-migrant (70%) and of the migrant households (65%) had an advanced school education or even a college education. 26% of the non-migrant and 22% of the migrant households are female-headed.

With respect to the status of employment, the figures for both groups are also nearly identical; 78% of the non-migrant and 79% of the migrant heads of household are currently unemployed, not able to work or have no permanent work place. A significant difference between the two groups can be found with respect to the question of land ownership: 90% of the non-migrants but only 54% of the migrants owned the land and the house they lived in before the tsunami.

Concerning the question of possession of motor vehicles (cars, motorbikes, etc.) and boats, there are no significant differences between the two groups: 2% of the non-migrant and 1% of the migrant households still own a boat after the tsunami, whereas 11% of the households of each group still own a motorized vehicle.

Being asked "how are your current living conditions compared to those before the tsunami?", 79% of the non-migrant and 84% of the migrant households answered with "worse than before". Less than one percent in each group state, that their living conditions are now better than before the tsunami.

10.3.3 Information and migration costs

Considering the migration and information cost variables, the differences between migrants and non-migrants turn out to be very marginal. 72% of the non-migrants and 75% of the migrant households lived in their areas for more than 20 years, and 60% of the non-migrant and 68% of the migrant household heads are members in at least one organization. Thus, the affiliation to and the network existing in the place of origin do not seem to affect the decision of a household to migrate or not.

Also regarding the question if the household has relatives living at the new place (or a possibly new place), the shares of respondents are identical: 46% of the non-migrant households and 46% of the migrants have relatives at the (or at a possible) new place.

Interesting is the fact, that only 70% of the migrants had access to information (TV, radio, etc.) whereas 84% of the non-migrant group had information access right after the catastrophe has happened. This can be seen as a hint, that information access probably has a rather discouraging effect on the migration decision.

10.3.4 Household characteristics

An interesting fact is that there seems to be no real difference between the group of migrants and the non-migrants concerning the characteristics of the head of household: 6% of the non-migrant household heads and 7% of the migrant heads are 30 years old or younger, 70% of the non-migrant household leaders and 68% of the migrant heads are between 30 and 60 years old, and finally, the share of non-migrant household heads, being older than 60 years is 24%; the corresponding figure for the migrant group in this age category is just 2 percentage points higher.

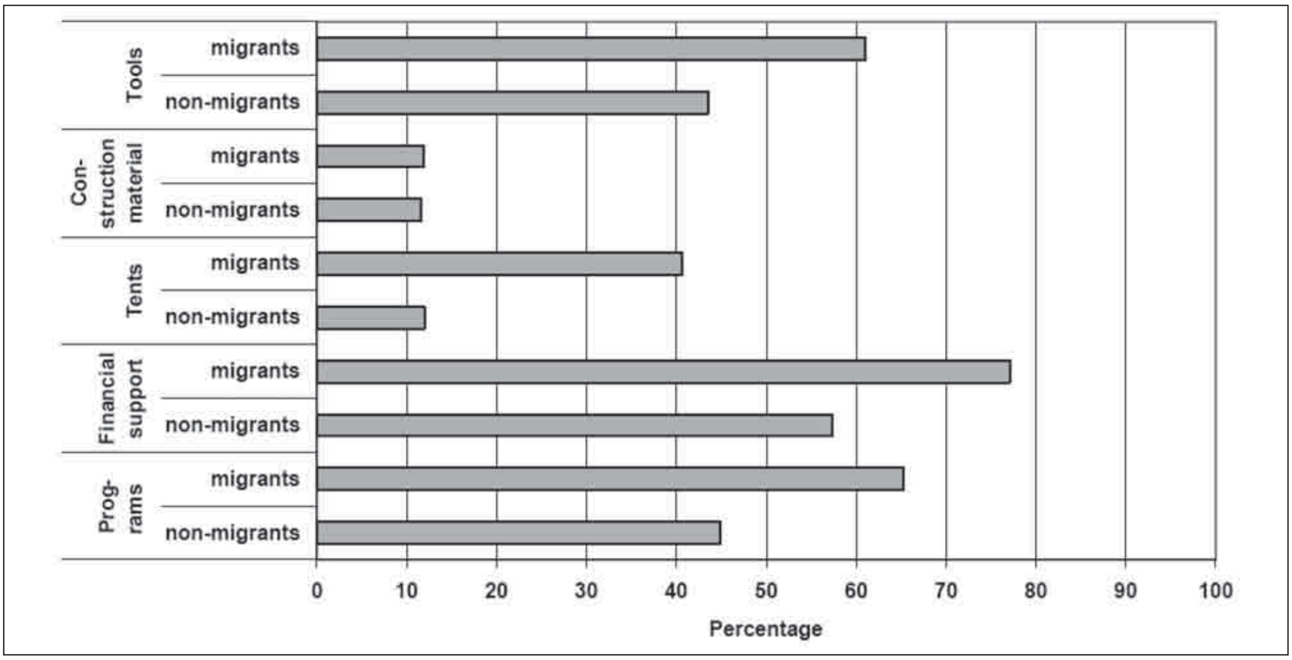
Almost astonishing is the response to the question "Do/ did you have confidence of finding a new job at a (possible) new place?", 65% of the non-migrant households state that they are confident in finding a new job, if they went to a new location, and 68% of the migrant households are confident in finding a new job at their (possible) place of reception.

13% of the non-migrants households and 23% of the migrant households now have fewer household members than before the tsunami. For the majority of both groups (84% and 74%) the number of household members is the same as before the tsunami. Just 2.8% of the non-migrant and 3.4% of the migrant households state, that the number of their members now has increased in comparison with the situation before the tsunami. The detailed reasons for the increase or decrease of the household sizes have not been analyzed further in detail.

Concerning the ethnic composition, the survey has shown that the share of Sinhalese households within the group of migrants is nearly 10 percentage points higher (77%) than within the non-migrant group (68%). The remaining 23% and 32%, respectively households are Muslim (plus one Tamil household within the group of the non-migrants). The share of Sinhalese households within the total sample is 71%.

10.3.5 The support situation

Figure 46: Percentage share of households within the non-migrant and migrant group that received financial, material and program support



Source: U. Grote, S. Engel, B. Schraven

Many different support activities were initiated to help the people in the tsunami-affected areas. Concerning the provision of food there are no differences between migrants and non-migrants; 94% of each group stated, that they received food from an organization or a public institution after the tsunami. Also regarding the participation in "work for food" programs the differences are very low: 43% of the migrant and 40% of the non-migrant households have participated in such programs. But there are differences concerning:

- financial support (which contains direct financial aid as well as subsidized and non-subsidized loans and credits); and
- material support (which contains the receipt of construction material, tools and/ or other equipment and tents).

10.4 Regression analysis

The survey data were used to empirically assess the factors which determine the probability of a household to migrate after the tsunami or not. We assumed a logistic distribution of the random error terms. The definition of the variables used in the regression analysis is presented in Table 17.

Table 17: List of variables used in the econometric analysis

sea_exp	=1 if the household has had bad experiences with the sea before the tsunami, =0 otherwise
ownership	=1 if the household owns the land and the house they lived in before the tsunami, =0 otherwise
house_damage	=1 if the house is heavily destroyed, =0 otherwise
hhh_age	Age of the head of household in years
info_access	=1 if the household had any kind of information access (TV, radio, internet, etc.) right after the tsunami, =0 otherwise
male_hhh	=1 if the head of household is male, =0 otherwise
education	=1 if the head of household has a higher education, =0 otherwise
membership	=1 if household is member in at least one organization, =0 otherwise
years_in_area	Years the household has lived in the area before the tsunami
relatives	=1 if the household has relatives or friends in the new area or a possible new area, =0 otherwise
affected	=1 if the household has one or more members which were killed, seriously injured or are still missing, =0 otherwise
affe_owner	=1 if affected = 1 and ownership =1, =0 otherwise
boats	=1 if the household still owns one or more boats, =0 otherwise
motorveh	=1 if the household still owns one or more motorized vehicles, =0 otherwise
root_pci	Square root of per capita income of the household;, =0 otherwise
sinhalese	=1 if the household is Sinhalese; =0 otherwise
ftt_support	=1 if the household has received financial and/ or material support in form of tents and/ or tools, =0 otherwise
construct	=1 if the household has received construction material, =0 otherwise (485 cases)

Table 18: Logit regression results

	with variables ftt_support and construct			without variables ftt_support and construct		
Variables	**Coef (Std. Err.)**	**P>|z|**	**Marginal Effect**	**Coef. (Std. Err)**	**P>|z|**	**Marginal Effect**
sea_exp	1.57 (0.42)	0.00**	0.36	1.67 (0.42)	0.00**	0.39
ownership	-2.87 (0.50)	0.00**	-0.61	-2.58 (0.46)	0.00**	-0.57
house_damage	1.49 (0.35)	0.00**	0.32	1.75 (0.34)	0.00**	0.39
hhh_age	0.01 (0.01)	0.37	0.00	0.01 (0.01)	0.40	0.00
info_access	-0.77 (0.39)	0.05**	-0.17	-0.75 (0.39)	0.05**	-0.17
male_hhh	0.51 (0.39)	0.19	0.10	0.55 (0.38)	0.15	0.11
education	-0.74 (0.34)	0.03**	-0.14	-0.67 (0.34)	0.04**	-0.14
membership	0.03 (0.16)	0.87	0.01	0.11 (0.15)	0.48	0.02
years_in_area	0.01 (0.01)	0.25	0.00	0.01 (0.01)	0.16	0.00
relatives	0.82 (0.32)	0.01**	0.17	0.77 (0.32)	0.01**	0.17
affected	-1.74 (0.73)	0.02**	-0.27	-1.35 (0.72)	0.06*	-0.23
affe_owner	2.32 (0.87)	0.01**	0.52	1.92 (0.85)	0.03**	0.45
boats	0.02 (1.21)	0.99	0.00	0.30 (1.21)	0.81	0.07
motorveh	0.17 (0.49)	0.73	0.04	0.31 (0.47)	0.51	0.07
root_pci	0.00 (0.01)	0.60	0.00	0.00 (0.01)	0.43	0.00
sinhalese	1.34 (0.40)	0.00**	0.24	1.38 (0.40)	0.00**	0.25
ftt_support	1.45 (0.53)	0.01**	0.24			
construct	-0.51 (0.51)	0.32	-0.10			
_cons	-2.12 (0.95)	0.03		-1.43 (0.87)	0.10	

Dependent variable: migra-wo-irr; n=324 cases
** Significant at the 5% level; * significant at the 10% level
Note: The marginal effects for this and the following logistic regressions were estimated at the means.
Source: Own calculations

The regression results from the econometric analysis are presented in Table 18. The dependent variable is a dummy variable reflecting the decision of the household to migrate after the tsunami to reduce its vulnerability or not. In general, the results are reasonably robust to changes in the set of independent variables included in the regression. Additionally, Table 18 presents the same regression including the additional variables "ftt_support" and "construct". This is done to shed some light on the effect of aid programs on the migration decisions. While the results on other variables are quite robust to this change, some caveat is in order, as the support variable may be endogenous, i.e., whether a household receives support may depend on some of the same variables affecting the migration decisions. The estimated relationship for the probability of migrating correctly predicts 83 % of the observations.

The results reveal that the decision of a household to migrate or not after a natural disaster like a tsunami is significantly influenced by safety considerations of the household. The two assumptioms that bad experiences with the sea which happened before the tsunami, and that the damage of the house due to the tsunami, both have a positive effect on the migration decision. Those two experiences seem to create a feeling of insecurity, so that people eventually decide to migrate to a different place.

Interestingly, the variable "affected" has a negative coefficient; thus, the hypothesis, that households who had one or more members dead, missing or seriously injured as a consequence of the tsunami, were less likely to migrate. The initial expectation was that the more affected households are also more likely to escape from the place where they made these bad experiences. However, the opposite effect found appears to indicate that households might be so traumatized that they just stay where they are, not being able to start a new existence at a new place.

As expected, the sign of the variable 'ownership' is negative and significant, indicating that households owning land and a house in the place of origin are less likely to move to a new place. This is intuitive, as migration implies a loss of these important assets for the household. However, the interaction term of the two variables 'affected' and 'ownership' has a positive and significant coefficient, indicating that land ownership did not affect as strongly the migration decision of households who had one or more members killed or seriously injured.

The decision to migrate to a new place also significantly depends on whether the household has any relatives and family ties to the place of reception. Households with relatives in the place of reception are more likely to move, indicating that these households can reduce migration costs through the existing networks at the receptor place. Also the number of years lived in the place of origin plays a role in the migration decision, given its relatively high significance level. However, the number of years a household has lived in the place of origin does not seem to stop the households from migrating to another place. Similarly, the social network at the place of origin, measured in terms of membership in local organizations, does not have a significant impact on the migration decision. Hence, even households which lived for many generations in the place of origin, decide to migrate.

The possession of assets like boats or motor vehicles does not seem to have any significant impact on the migration decision either. The hypothesis that households with a higher per capita income are more able to afford migration and thus more likely to opt for migration is not supported by the data. Age also does not have a significant effect, which is not surprising given the possible counteracting effects described above.

The education does influence the migration decision since it is significant at the 10% level. The result indicates that less educated households are more likely to move. This might be based on the fact that more educated households are better informed about the situation in the place of reception and are therefore more hesitant to migrate. On the other hand, it would have been also possible that educated households expect their employment opportunities to be higher at the place of reception, supporting them in the idea of migrating. However, the results imply that this effect is dominated by the information effect.

The results also indicate that male-headed households are more likely to migrate than female-headed ones. If we are correct in assuming that male household heads are less risk-averse than female heads, this seems to imply that the risk of finding unfavorable living conditions at the place of reception is valued more strongly than the risk of becoming a victim of another natural disaster.

Those households having access to information from the TV, radio, newspaper or even internet just after the tsunami had happened are less likely to move to another place. They might have received information about the difficult situation in alternative places of reception, or about the support to be received in the near future at the place of origin.

Finally, we find that households who have received support (financial and/or material) after the tsunami are more likely to migrate. The variable 'fm_support' turns out to be highly significant. However, this result needs to be taken with some degree of caveat, as support may be endogenous. However, when adding the variable to the regression equation, the results hardly change so that we conclude that the equation is reasonably robust to this change.

We also reestimated the model by considering only the households living within the 100 m zone before the tsunami happened, since this group of households might be considered as being more vulnerable than the households living outside the 100 m zone. Looking at the descriptive statistics of these 178 households, we find that 71 are migrants, 47 are classified as non-migrants since they returned to their homes, and 60 are still undecided whether to migrate or not. Interestingly, the direction of the results of the regression on the migration decision are comparable, however, the significance level is lower, which mainly is the result of the smaller sample size and the distribution of the variables between the migrant and non-migrant households.

10.5 Policy implications

A better understanding of the determinants and effects of the migration decision at the household level helps to define appropriate prevention, assistance and resettlement policies for people living in areas prone to natural disasters. The analysis presented here helps to improve such an understanding by developing a theoretical framework for the empirical analysis of the migration decision of households who have been hit by a tsunami.

We consider the area of the survey to be generally a high risk area, and those people living in the area are more vulnerable than those who migrate. By understanding the characteristics and motivations of the more vulnerable people who stay in the tsunami-struck area, compared with those who migrate or intend to migrate to safer places after the tsunami and who are therefore less vulnerable now, we can derive a picture about the needs of the people and possible policy support necessary to reduce the vulnerability of households.

Our empirical results show that households with one or more dead, missing or seriously injured members are less likely to migrate. This seems to indicate that affected people are traumatized. Psychological support programs are needed to help the affected people to overcome the trauma experienced by the tsunami.

The results indicate that people with higher education are less likely to migrate, implying that more educated people are better informed and more realistic about the difficult situation at the place of reception in terms of finding new employment or appropriate housing and support. Thus, employment programs in the place of reception can help to improve the living conditions at the place of reception and thereby encourage migration.

Households that opt to stay in the high risk areas are often land and house owners in their respective places of origin. They are not prepared to give up their property unless some compensation will be offered to them. In this case, alternative land and housing offers by the state would be needed to convince the non-migrant households to migrate to safer places.

Relatives in the places of reception help to motivate the affected people to migrate. They have the effects of pull factors since they are the sources of information and of social life for the migrating households. It is impossible to substitute for the family ties of a household by the state but the establishment of social networks, associations or meeting points can replace up to some extent the functions of family ties in the places of reception.

Finally, we find that receiving support (financial and/or material - excl. construction material) increases the likelihood that a household decides to migrate to a safer location. This implies that current support schemes might encourage people to leave the high risk area. Thus, these schemes turn out to be real "migration support instruments".

11 Conclusions and Recommendations

by J. Birkmann, N. Fernando, S. Hettige, S. Amarasinghe and T. Jayasinghem

11.1 Conclusions

This study aimed to provide information with regard to the vulnerability of coastal communities to tsunamis. The identification of the most vulnerable social groups, critical infrastructures and the built environment provides important information about those areas and groups that should be targeted first in emergency and rescue operations as well as in the reconstruction process. Local vulnerability assessment should also function as an evaluation tool to assess the current intervention and reconstruction strategies. Furthermore, the information should also be used in 'normal' situations to reduce vulnerabilities beforehand.

The study has revealed and underlined – based on analysis of the revealed and emergent vulnerability to tsunamis – that in Galle and Batticaloa, women, young children and elderly people were among the most vulnerable groups. This can be seen particularly in the results of the questionnaire-based household survey and partially also in the analysis of the census data (see Chapters 5, 6 and 9). However, there were also other determinant factors of vulnerability, such as the access to land, particularly for those who were living in the 100 meter zone (see Chapter 5).

With regard to future activities and preparedness plans it is important to target these most vulnerable groups first and as a priority in emergency situations, for example by disaster management strategies and evacuation plans. Moreover, specific awareness programmes should be set up in order to increase the awareness of these groups of their particular vulnerabilities, and to strengthen their coping and mitigation strategies. Lack of any knowledge of tsunamis was revealed in the household survey and stated as a serious risk factor in the focus-group discussions (see Chapters 5, 6 and 7).

In addition, the findings on the vulnerability of the physical environment, built infrastructure and human impacts in and outside the 100m zone, underline that urban planning and land-use management are also important key actors to promote vulnerability reduction. Buildings currently reconstructed in the 100m zone need different preparedness measures than those outside the zone. Since the likelihood of being killed by the tsunami was, in both cities, twice as high in the 100m zone than outside, it is important to establish specific early-warning and evacuation concepts in the 100m zone, which allow for an effective reduction of vulnerability through early warning, evacuation and improved physical structures. Furthermore, the results of damage analysis of the built environment in Batticaloa underlined that heavy destruction went beyond the first 100m in the selected GN Divisions in Batticaloa. This means that that a general 100m buffer zone as a mitigation strategy is not appropriate: a buffer zone needs to take into account the specific local context. Local vulnerability assessment tools and their adaptation to the local context might improve mitigation strategies.

The results of the study also indicate that underlying and emergent vulnerabilities that go beyond the scope of disaster management have to be addressed. For example, in Galle there is clear evidence that the lack of access to land makes people even more vulnerable in the reconstruction process, particularly squatters in the 100m zone. Therefore, urban planning and development programmes for coastal communities have to promote vulnerability reduction and disaster-resilient communities by targeting the problem of access to land. One should use the opportunities provided by the reconstruction process to link development and reconstruction with vulnerability reduction and poverty eradication.

The identification of the most vulnerable groups and areas provides important information for relief organisations, allowing them to target those groups who need help most. In addition, the migration study gives in-depth information on the motivations of people to migrate or to resettle in the same place as before or elsewhere. This is particularly relevant for relocation strategies, since not only the reduction of exposure to the hazard, but also people's expectations, have to be addressed and taken into account if a relocation strategy is to be sustainable.

The analysis of exposure with regard to critical infrastructures and sectors allowed a first estimation of those infrastructures and sectors which are highly exposed. However, actual or specific 'exposure' might also be influenced by road systems, built infrastructure, small rivers and canals. In Galle, for example, the bus station was highly affected by the Tsunami wave, although it was located in the 200m-300m zone from the sea. The critical infrastructure analysis based on assessment of the degree of exposure of critical infrastructure in the 100m zone – as defined by the government or on an elevation model – needs to be seen as a first step and overview. For specific emergency plans more in-depth studies are required.

Regarding the analysis of the vulnerability of various social groups, limitations and difficulties are particularly apparent in terms of income data. Although income-related vulnerability measures are often appealing and of high interest to decision-makers, income data at a fine resolution is often difficult to grasp. For example, the income figures in the post-tsunami census are questionable, and post-tsunami income data captured in the household survey was not reliable enough. Households might want to hide their new poverty or they might be getting external financial support.

The intention to combine different methodologies and data sources seems to be an important step forward in overcoming the specific limitations of a single methodology. For example, it would be very helpful if remote sensing were able to identify more precisely the number of squatters in a specific local unit (e.g. GN Division) in order to estimate the most vulnerable areas. Given the nature of such settlements, they might not only lead to higher losses but may even impede the speedy evacuation of people following an early warning. This issue needs further investigation.

In addition, uncertainty is a major problem in the field of resettlement and reconstruction. As people indicated in the focus group discussions, major problems arise from the lack of information and the uncertainty over whether it is possible to restart business in the same place or whether the household will get an alternative place to live.

Overall, the findings presented in this study are based on a rapid assessment over an eight-month period of applied research. The assessment of vulnerability will be a key issue for the future, especially with regard to the reconstruction process and implementation of an early-warning system. In this context the South Asian Disaster Report (2006) underlines that efforts at integrating disaster management into local planning have been ad hoc and that if these plans do exist they have not been integrated yet.

Since the buffer zone has now been reduced to 50m, allowing the proliferation of settlements and other structures close to the sea, it will be important to know more about the specific vulnerabilities of different social groups or critical infrastructure in this zone in order to be prepared for emergency situations and future coastal hazards.

Cost-Benefits of Different Methodologies

The cost-benefits of the different methodologies have to be taken into account when examining the usefulness of various tools to estimate vulnerability. While a first and general estimation of demographic and social vulnerability is often feasible using census data (see Chapter 9), the more in-depth questionnaire methodology allows a better understanding of the specific vulnerability patterns of different social groups. For example, the current census data does not provide sufficient and adequate information about elderly people and their revealed vulnerability. On the other hand, the analysis of available census data is often processed within one or two months, while the development, testing and implementation of a household questionnaire survey takes at least four to six months. The remote sensing analysis allows for estimating the impact of disasters on physical structures throughout the world. However, although satellite is able to provide actual information for most parts of the world, the methodology is costly: one satellite image with the high resolution required to assess the structure of a single building could cost around US$5,000-10,000. Special software and trained personnel are also needed.

Furthermore, remote sensing analysis also depends on ground truth data to verify the classification methodology. This means that a combination of different methods is needed. Therefore, an important advantage of using different methodologies is that they can be combined and these synergies exploited. For example, the household survey using structured questionnaires conducted by enumerators also captured information on house type and its damage as well as the socio-economic conditions of the household. This is important information for the remote sensing analysis and verification of the classified settlement structure types. However, due to the short time span and the complicating fact that Galle municipality encompassed a very mixed urban structure, it was not possible to use an automated programme to generate information about different settlement structure types (see Chapter 3).

Overall, the results of the "Rapid and Multidimensional Vulnerability Assessment at the Local Level in Sri Lanka" in two selected cities should be seen as a first step. Future investigations need to strengthen our understanding of how to combine different methodologies effectively and how to measure vulnerability at different levels. The Road Map, as an important action plan to promote disaster-resilient reconstruction and societies, underlines in Sri Lanka the necessity to develop a national vulnerability and risk map (MDM 2005). This should be seen as a priority task. One also has to explore how to integrate this information in development and emergency preparedness plans to ensure that vulnerability assessment supports activities towards disaster-resilient communities in a practical manner.

Finally, it is important that vulnerability assessment be transformed into a continuous monitoring system. This would allow better and continuous information about the medium and long-term impacts of the December 2004 tsunami – such as information about the major difficulties in recovering, and the consequences of different intervention tools undertaken to reduce the vulnerability of coastal communities.

11.2 Recommendations

Estimation and assessment of vulnerability will be a key issue for the future as well, especially with regard to the reconstruction process and implementation of an early-warning system. On the basis of the Rapid and Multidimensional Vulnerability Assessment the following recommendations – particularly for policy-makers and development agencies – can be derived:

- The most vulnerable groups, such as women, young children and the elderly, should be targeted as priorities, and their specific vulnerabilities need addressing in matters of early warning, evacuation and emergency management, and awareness-raising.
- The reconstruction process should accommodate the above-mentioned most vulnerable groups.
- Major government activities were concentrated on relief measures during and after the tsunami. More emphasis must be placed on integrated reconstruction approaches. For example, more attention has to be paid to the lack of access to land, particularly in Galle, and to housing design and physical structure (tsunami-resistant buildings) in high-risk zones.
- It is important in reconstruction and relocation to take into account specific livelihood patterns and cultural issues in order to ensure that the new location suits people's livelihood requirements.
- A top-down approach like that of the 100m buffer zone was inappropriate in many places and had a negative impact. Local assessment tools (as presented in the study) and more participatory approaches are needed to ensure that communities and affected households can define and articulate their own needs.
- The study revealed major differences in potential recovery time between the tsunami-affected households in Galle and those in Batticaloa. This shows the need for more strategic planning and reconstruction at national and sub-national levels.
- It is necessary to target the institutional dimensions of vulnerability particularly in regions where governance is difficult (e.g. in conflict zones such as Batticaloa).
- More emphasis must be given to the combination and interlinking of vulnerability and natural hazards, such as tsunamis, and creeping vulnerabilities, such as armed conflicts.

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List of Figures

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