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EXECUTIVE SUMMARY

This report is intended to present a comprehensive review of the existing works on tsunami resilient communities through the analysis of available bibliography and identify key indicators and gaps in the field. As such, this report serves as a guiding document in that the literature reviewed in this report can be of benefit for various tasks within the WP9 (i.e. Task 9.2, 9.3, 9.4, 9.5, and 9.6). The main conclusions from this report are as follows:

- The present literature definitely lacks an integrated understanding and assessment of community resilience to tsunamis. Furthermore, there is a certain level of disorganization and a lack of integration to a great extent.
- Studies on tsunami resilience are less extensive on social science aspects compared to technical aspects which are mostly dealt by engineers and scientists.
- The literature on tsunami crisis management is sparse.
- There is substantial literature on accessibility mapping and evacuation simulations, which is well-organized and well-integrated.
- The availability of educational materials and activities for communities facing tsunami risk is rapidly increasing especially with the help of Internet sources. However, effectiveness of these efforts must be analysed for gaining insight into the link between such efforts and achieved recovery level.
- Most of the literature reviewed in respect to the topics identified within the Task 9.1 is concentrated particularly on the Pacific & Indian region. Unfortunately, tsunami resilience has not been of considerable concern in Europe as compared to other tsunami-prone regions in the world. The project ASTARTE is therefore very much valuable for building tsunami resilient societies in general.

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Abstract (for dissemination)	<p>This report is intended to present a comprehensive review of the existing works on tsunami resilient communities through the analysis of available bibliography and identify key indicators and gaps in the field. As such, this report serves as a guiding document in that the literature reviewed in this report can be of benefit for various tasks within the WP9 (i.e. Task 9.2, 9.3, 9.4, 9.5, and 9.6).</p> <p>The first part of the report gives a general introduction to community resilience and discusses briefly its indicators. Among the indicators, risk perception and preparedness are further explained in detail. Then in the second part the concept of tsunami resilience is introduced and characteristics of tsunami resilient societies are described. Review of existing work on (1) preparedness skills and attitudes for facing tsunami hazard, (2) tsunami crisis management, (3) accessibility mapping and evacuation simulations, (4) tools dedicated to tsunami awareness and preparedness are also presented next. Lastly, the major conclusions based on the gaps identified in the literature are summarized and recommendations for future studies are highlighted.</p>
Keywords	Tsunami, resilience, preparedness, risk perception, crisis management, accessibility, evacuation, tsunami awareness, and educational tools.

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Table 1. Main components of community resilience (Birkmann et al., 2012b).

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Table 3. Social dimensions of building tsunami resilient societies.

ABBREVIATIONS AND ACRONYMS

DRR	Disaster Risk Reduction
IDNDR	International Decade for Natural Disaster Reduction
IOC/UNESCO	Intergovernmental Oceanographic Commission of UNESCO
NEAM	North-Eastern Atlantic, the Mediterranean and connected seas
NTHMP	National Tsunami Hazard Education Program
UNISDR	United Nations International Strategy for Disaster Reduction

DEFINITIONS

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CHAPTER 1 INTRODUCTION

Tsunami, a relatively rare phenomena compared to other natural events affecting coastlines around the world, is a major natural hazard posing significant flood risk for coastal communities. The recent experiences from the Pacific and Indian Ocean (the 26 December 2004 tsunami in Southeast Asia and the great East Japan earthquake and tsunami of March 2011) have clearly demonstrated how devastating the scale of tsunamis' potential consequences (i.e. human suffering, damage to physical structure and economic costs) can be. These events reveal the very fact that there is a compelling need for reducing the future vulnerability to tsunami damage and destruction in coastal areas. Therefore, increasing societies' resilience to tsunamis in at-risk areas is of fundamental importance for minimizing damage and preventing loss of life. This can be accomplished through a variety of disaster planning (risk management and crisis management) activities based on effective strategies, and efficient implementation of different preparedness and mitigation measures - all together constituting main phases of tsunami (disaster) risk management cycle.

This report is the first version (V1.0) of the Deliverable 9.2 of the Work Package 9 (WP9) – Task 9.1 as completed in April 2014. The report is intended to present a comprehensive review of the existing works on tsunami resilient communities through the analysis of available bibliography and identify key indicators and gaps in the field. As such, this report serves as a guiding document in that the literature reviewed in this report can be of benefit for various tasks within the WP9 (i.e. Task 9.2, 9.3, 9.4, 9.5, and 9.6).

The literature, as a first impression, is very rich in studies on physical science and engineering aspects of tsunamis and mitigation measures while it indicates a relatively weaker focus on social science aspects of tsunami hazard and risk management. It should be also mentioned that although there are many studies devoted to understanding (and analysing) community resilience for other natural hazards (mostly earthquakes and floods to a lesser extent) there have been a relatively limited number of tsunami-specific studies. Therefore, in this report a broader literature is overviewed with respect to community resilience, risk perception and preparedness in other natural hazards as well as in tsunamis.

The perception of negligible tsunami hazard in Europe – despite the occurrence of several notable tsunamis in the past affecting the shores of the North-Eastern Atlantic, the Mediterranean and connected seas (NEAM) region – is mainly due to the relatively infrequent occurrence of large tsunamis compared to the Pacific region (Dawson, Lockett & Shi, 2004). Such perception has substantially restricted the focus of related literature in terms of case studies mainly limited so far to mostly Asia and America.

This situation, for the reasons stated above, enabled us to identify the gaps in this research field and make recommendations for the work to be carried out within the subtasks of WP9, which are essentially aimed at identifying the key components of tsunami resilience, the characteristics of a tsunami resilient society, and the enabling conditions for its implementation in the NEAM region.

Community resilience is a principal area of research (and practice) aimed at building resilient societies to disasters. An important objective of this report, thus, is to provide a comprehensive perspective on the very basic concept of community resilience, particularly within the context of

natural hazards. The first part gives a general introduction to community resilience and discusses briefly its indicators. Among the indicators, risk perception and preparedness are further explained in detail. Then in the second part of the report the concept of tsunami resilience is introduced and characteristics of tsunami resilient societies are described. Review of existing work on (1) preparedness skills and attitudes for facing tsunami hazard, (2) tsunami crisis management, (3) accessibility mapping and evacuation simulations, (4) tools dedicated to tsunami awareness and preparedness are also presented in this part. Lastly, the major (preliminary) conclusions based on the gaps identified in the literature are summarized and recommendations for future studies are highlighted.

1.1. Community resilience

The concept of resilience has been employed in many fields of research ranging from social sciences to environmental sciences as well as engineering sciences (e.g. physics, mathematics, economics, psychology, sociology and human geography) (Bruneau et al., 2003; Gallopin, 2006; Norris, Stevens, Pfferbaum, Wyche & Pfefferbaum, 2008; Alexander, 2013). While sociology discusses the term in the context of resilient communities, psychology focuses on the individual aspects (although taking into account how the individual is influenced by his or her social, cultural and physical environment). The term resilience has been popularly used in the context of disaster risk reduction (DRR) as well, yet with different interpretations and usages causing confusion (Alexander, 2013). Representative definitions of resilience at different levels of analysis (e.g. physical, social, individual, community) can be found in Norris, Stevens, Pfferbaum, Wyche & Pfefferbaum (2008).

Adaptability of resilience concept to various uses and contexts in different ways makes resilience studies focal within various sciences as demonstrated in Figure 1. A comprehensive literature review of resilience research is provided in emBRACE Working Paper 1.1 (Birkmann et al., 2012a). In this report, the concept of resilience is addressed under five perspectives from different disciplines. These perspectives are, namely, psychological, organizational and institutional, ecological and socio-ecological, critical infrastructure, and community-focused (practical). A detailed review on how resilience is assessed and operationalized in existing studies can be found in the Working Paper 1.2 of the emBRACE project (Birkmann et al., 2012b).

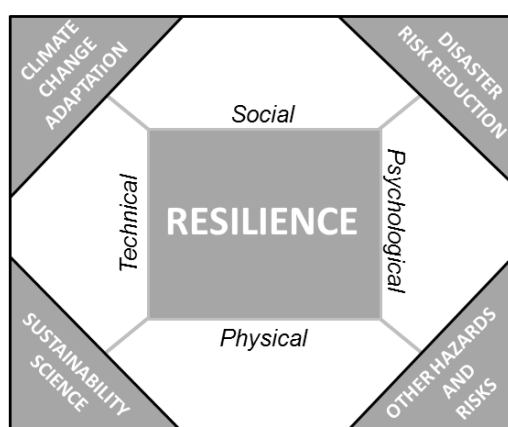


Fig. 1. The place of resilience studies linking various sciences (Adapted from Alexander, 2013).

Living with natural disasters and their consequences has become today a way of life challenging the life of communities in at-risk areas all around the world. This necessitates developing capacities and

establishing adaptive mechanisms for such societies (and their members) to co-exist with natural hazards, which is especially more challenging for low probability-high impact hazards like tsunamis. Community and societal mechanisms are crucial for sustainability of community capacities and functions. Yet, disruption of these mechanisms is, unfortunately, inevitable in case of occurrence of natural disasters (Paton, 2006). The concept of resilience (and vulnerability) is important in determining the response capacity of people in the face of natural hazards (Gaillard, 2007; Adger, Hughes, Folke, Carpenter & Rockström, 2005). (Note: Vulnerability is of a complementary nature to that of resilience; however, the concept of vulnerability is not reviewed within the scope of this report.) Based on the notion of adaptive capacity (Klein, Nicholls & Thomalla, 2003), Paton & Johnston (2006) considers resilience as *“a measure of how well people and societies can adapt to the changed reality (whether from the disaster itself or the societal response to it)”*.

The United Nations International Strategy for Disaster Reduction defines resilience as *“the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions”* (UNISDR, 2009, p. 24). According to Gaillard (2007) *“resilient communities are able to overcome the damages brought by the occurrence of natural hazards, either through maintaining their pre-disaster social fabric, or through accepting marginal or larger change in order to survive. The concept of resilience is thus intimately linked to the concept of change. Post-disaster changes within the impacted society may be technological, economic, behavioural, social or cultural in nature”*. In relation to natural hazards and disaster risk reduction, resilience can be analysed and discussed in different levels of concepts (Paton, 2006):

- (i) *Resilience within the context of adaptive capacity*
- (ii) *Resilience as a social resource (e.g., facilitating community members’ commitment to reduction and readiness activities)*
- (iii) *Resilience at a behavioural level (e.g., encouraging the sustained adoption of preparatory adjustments and the ability to respond and adapt to adverse hazard effects.)*
- (iv) *Resilience based on the social, cultural and environmental contexts within which societal activities occur.*

Twigg (2009) remarks that *“a focus on resilience means putting greater emphasis on what communities can do for themselves and how to strengthen their capacities, rather than concentrating on their vulnerability to disaster or environmental shocks and stresses, or their needs in an emergency”*. According to the Hyogo Framework (ISDR, 2005) *“the expected outcome of building resilient societies is substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries.”*

The idea of community resilience to disasters has evolved following the efforts of the United Nations, e.g. International Decade for Natural Disaster Reduction (IDNDR; 1990-1999), the United Nations International Strategy for Disaster Reduction (UNISDR ; 1999). Unfortunately, the literature lacks a thorough conceptualization of the term ‘community resilience’ (Birkmann et al., 2012b). Community resilience is defined by Norris et al. (2008) as a process linking a set of networked adaptive capacities (i.e. resources with dynamic attributes - robustness, redundancy, rapidity) to a positive trajectory of functioning and adaptation in constituent populations after a disturbance. A definition of community resilience is provided by the UK civil protection Lexicon (Cabinet Office, 2010):

“Communities and individuals harnessing local resources and expertise to help themselves in an emergency, in a way that complements the response of the emergency services.”

In her study analysing community resilience as an Indicator of social sustainability, Magis (2010) defined community resilience as *“the existence, development, and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability, and surprise”* and listed its dimensions as resource development, community resources, active agents, collective action, strategic action, equity, impact, and resource engagement (see Figure 2).

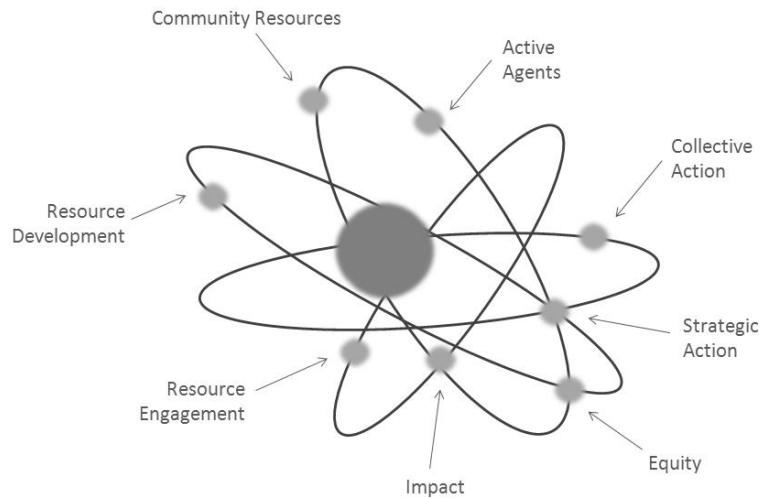


Fig. 2. The dimensions of community resilience (Adapted from Magis, 2010).

In their framework, Norris et al. (2008) distinguishes community resilience with four primary sets of adaptive capacities that together form a base for disaster readiness: (i) economic development, (ii) social capital, (iii) information and communication, and (iv) community competence. It is emphasized that there are political, economic and natural factors operating at larger ecological levels but influencing them at the community level.

Magis (2010) stated that the intentional development of personal and collective capacity in the members of resilient communities helps them to respond to and influence change, to sustain and renew the community, and to develop new trajectories for the communities' future. This is exactly the challenge for communities in disaster-prone areas. In this respect, community resilience is an important issue in areas prone to natural hazards where there is a significant potential for these events to become disasters due to the hazard itself (e.g. its nature and scale) and/or human activities and development (e.g. urbanization, poor infrastructure and planning).

The role of community resilience is substantial for achieving better disaster risk management, i.e. through effective and efficient disaster mitigation and preparedness, response and recovery. Consequently, the research on understanding, delineating and measuring community resilience to disasters has attracted increasing focus in recent years (see, e.g. Bruneau et al., 2003; Cutter et al., 2008; Daly, Becker, Parkes, Johnston & Paton, 2009; Sherrieb, Norris & Galea, 2010; Price-Robertson & Knight, 2012; Reams, Lam & Baker, 2012; Kafle, 2012; Ainuddin & Routray, 2012; Jordan & Javernick-Will, 2012; Li, 2013).

It has been recognized in the disaster literature that developing a framework for community resilience is necessary (Paton & Johnston, 2001; Basolo et al. 2009, Solberg, Rossetto & Joffe, 2010). The resilience literature in disaster context is large and complicated, yet not very well defined regarding the perspectives employed and the components studied. Despite valuable efforts on delineating community resilience (e.g. Paton & Johnston, 2001; Bruneau et al., 2003), there is still a definite need for a comprehensive model of community resilience. A major aim of research, therefore, should be to develop theoretical frameworks and empirically validate these on different case studies (i.e. having different communities, experiencing different natural disasters, see e.g. Paton, 2013). The ongoing research project (funded by EU-FP7) called “emBRACE - Building Resilience Amongst Communities in Europe” is an important contribution in this area. emBRACE is aimed at understanding the indicators of community resilience to natural hazards and how community resilience to natural hazards can be developed in Europe (for more detailed information about the project see <http://www.embrace-eu.org/>). There are 5 case studies within the project: river floods in Central Europe (Germany, Poland, Czech Republic); earthquakes in Turkey; multiple hazards in South Tyrol, Italy and Grisons, Switzerland; heat-waves in London; combined fluvial and pluvial floods in Northern England. The project provides insights into key components of community resilience to natural disasters. By exploring the interaction between different dimensions and components of resilience, the factors shaping community resilience are studied (see Birkmann et al., 2012b). Most importantly, a theoretical framework for community resilience to natural disasters will be developed based on the factors identified.

Among various frameworks developed for community resilience (e.g. Bruneau et al., 2003; Cutter et al., 2008), this report briefly illustrates a generic model developed as a result of recent research in Australasia (Paton, 2010; Paton, 2012 – as cited in Johnston et al., 2013). In this model, the indicators are considered at three separate levels (i.e. individual, community, and societal/agency) which are interdependently related to each other as depicted with arrows in Figure 3. These levels feature psychological and social factors that facilitate (or lessen) preparedness behaviour of individuals and communities. At the individual level, the identified indicators are outcome expectancy, denial, fatalism, action coping/self-efficacy, and critical awareness. Acting as a motivating factor for people to prepare, critical awareness is very much influenced by the risk perception of individuals. The indicators for the community level include place attachment, community participation, and collective efficacy. The societal/agency level on the other hand stands for the indicators of empowerment (i.e. empowering settings supporting community-led initiatives) and trust. The model identifies the requirements of preparedness (resilience/adaptive capacity) as well – which in turn result in empowering people and communities to prepare for a disaster.

A number of issues still remain to be addressed within research on community resilience for natural disasters - particularly related to quantification of resilience and its indicators. First and foremost, the selection of indicators measuring resilience (which can reflect not only the hazard but also the community characteristics) is problematic in the sense that different researchers may consider different indicators depending on their research area and purpose. It is thus crucial to examine all the possible factors that facilitate resilience and establish a framework for modelling the factors that influence resilience (Paton & Johnston, 2001). Secondly, the validation process is a major challenge. The adequacy of hypothesized framework must be evaluated using quantitative metrics rather than qualitative data. This is especially important for understanding performance of a framework of community resilience and its applicability for different communities. (It is also necessary to compare

different frameworks of community resilience against a specific natural disaster). Thirdly, attention must be given to both social, natural and physical aspects of resilience, and also their relatedness (Reams et al., 2012). In relation to the first issue, this report touches upon indicators of community resilience next.

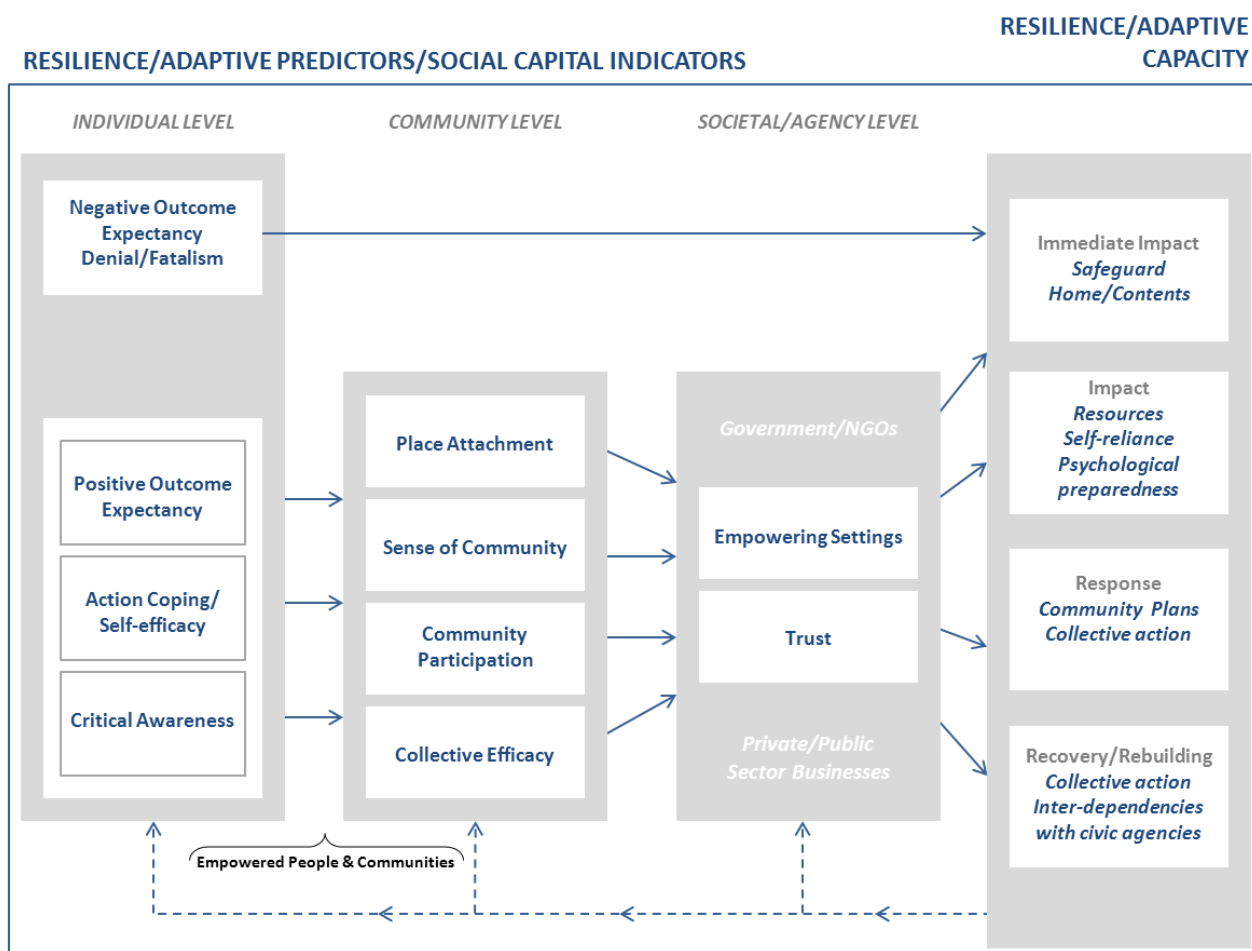


Fig. 3. Community resilience model (Adapted from Johnston et al., 2013).

1.2. Indicators of community resilience

In the literature, there are various frameworks based on varying key components of resilience, and accordingly having different indicators, available for assessing resilience in different contexts and for different dimensions (e.g. economic, technical). With the challenges this situation brings, identifying indicators of community resilience (and measuring resilience) has also become an increasingly demanding research area, producing many studies. Becker, McBride & Paton (2013) summarizes the indicators of resilience identified by the up-to-date research efforts. These indicators represent individual, community, and institutional factors and are: self-efficacy (the person’s perceived ability to actually to perform or carry out protective measures), collective efficacy (the extent to which the community can actually engage in preparedness behaviours), outcome expectancy (negative/positive; the extent to which the person believes that his/her actions can effectively mitigate hazard effects), critical awareness (the extent to which people think and talk about hazard), action coping (problem-focussed vs. emotion-focussed coping), leadership, community participation, articulation of problems, planning, place attachment(sense of attachment to place), empowerment (“citizens’ capacity to gain mastery over the affairs and to deal with issues and opportunities using

intrinsic resources” – Paton, 2007), trust (between individuals and agencies/institutions related to hazard management), sense of community (feeling attached to people and places), social norms, personal responsibility, responsibility for others, emotions and feelings, previous experience (of disasters), demographic characteristics, resource issues (e.g. affordability of preparedness measures, time availability), psychological preparedness. The literature reviewed within the project emBRACE suggests that there are often different indicators used to assess the same components of resilience. Birkmann et al. (2012b) distinguishes resilience among five different contexts: psychological, organizational and institutional, ecological and socio-ecological, critical infrastructure, and community-based. In the deliverable (D1.2) of the emBRACE project, 15 main components (synthesized out of 81) identified based on the examples from the general literature are given in Table 1. Le De, Gaillard & Friesen (2013) points out the importance of remittances as a coping mechanism for reducing vulnerability to disasters in the least wealthy countries. From this perspective, remittances can be alternatively considered as yet another component of community resilience to disasters.

Table 1. Main components of community resilience (Birkmann et al., 2012b).

▪ <i>Governance (Actors, Institutional Arrangements, Organisations)</i>	▪ <i>Resources</i>
▪ <i>Education, Research, Awareness and Knowledge</i>	▪ <i>Infrastructure and Technical</i>
▪ <i>Information and Communication</i>	▪ <i>Health and Well Being/ Livelihood</i>
▪ <i>Culture and Diversity</i>	▪ <i>Economic</i>
▪ <i>Preparedness</i>	▪ <i>Adaptive Capacity</i>
▪ <i>Response</i>	▪ <i>Coping Capacity</i>
▪ <i>Protection</i>	▪ <i>Innovation and Capital</i>
▪ <i>Exposure, Experience and Impact Severity</i>	

These are the key components and indicators which are, more in particular, valid in a natural hazard context. However, it must be born in mind that dependent relationships exist among different indicators. For example, economic development level of countries, thus communities, may directly affect preparedness level of communities. Intrinsic social conditions within a community (exposed to a particular hazard) are influential on resilience capacity of that society experiencing the natural hazard (Gaillard, 2007). These mutual influences necessitate the consideration of local features varying among communities (and the nature of the hazard too) for contextualizing community resilience for natural disasters (Paton & Johnston, 2001). One benefit of such understanding is that it can significantly contribute development of appropriate strategies for more effective disaster planning and management in an efficient manner.

Also of concern is validation of these indicators of resilience. Jordan & Javernick-Will (2012) states that assessment of how resilience frameworks lead to recovery may be used for this purpose. However, there are not many studies investigating the possible links between resilience measures (identified within a framework) to level of post-disaster recovery (Norris et al., 2008).

Preparedness is one of the key components of resilience. There are various psychological models developed (and empirically tested) for identifying the factors that facilitate and/or hinder individual mitigation/preparedness behaviours (i.e. hazard adjustments). The Person Relative to Event model (PrE) (Mulilis & Duval, 1995); the Protective Action Decision Model (PADM) (Lindell & Perry, 1992); Protection Motivation Theory (PMT) (Rogers, 1983); the social cognitive model of Disaster Preparedness (DPM) (Paton, Smith & Johnston, 2005), to mention but a few important models. All these models acknowledge the importance of risk (or hazard) perception and vulnerability appraisal.

Personal resources (e.g. high outcome and self-efficacy) are another main category of factors in these models. The aforementioned indicators of resilience accounting for knowing about methods of coping, having the skills to cope, and having adequate financial and community resources are also reflected within the models as factors that facilitate/hinder preparedness activities. Although not considered in all of the models, it is also necessary to highlight factors that may hinder preparedness behaviours. The research has shown that denial (i.e. not acknowledging the risk), fatalism (i.e. belief that no action can change a predetermined destiny), avoidance (i.e. not thinking or talking about risks), optimistic bias (i.e. a belief that the person is in a better position compared to others and that nothing will happen to them), externalisation of responsibility (i.e. expectation that outside agencies are responsible for mitigation/preparedness measures) and past experience (with no substantial loss due to a hazard event) were highly influential (Kasapoğlu & Ecevit 2003 ; Mishra, Suar & Paton, 2009 ; Rüstemli & Karanci, 1999 ; Sattler, Kaiser & Hittner, 2000). All these factors reflect the risk perception characteristics of individuals. In this respect, it is vital to understand the relationship between risk perception and preparedness decisions, and analyse the mediating factors of such relationship.

If one focuses on individual components of community resilience, risk perception and preparedness are among the most salient associated indicators in the context of natural hazards and DRR. Therefore, this report deems risk perception and preparedness as key indicators of community resilience against natural disasters. In the following sections these key concepts are discussed.

1.3. Risk perception

In disaster risk management (at both individual and collective levels) risk perception is an indispensable factor contributing to increased public understanding of risk – which enables disaster planners and managers to prompt communities and individuals to involve in necessary protective actions (Twigg, 2013; Twigg, 2004; Birkholz, Muro, Jeffrey & Smith, 2014). Addressing the issue of risk perception and incorporation of findings from risk perception studies in natural hazards research into disaster management practices can thus potentially enhance our ability to build more resilient societies against disasters (e.g. through training programs, improved risk communication strategies, and active stakeholder and community involvement) (see e.g. Johnston et al., 2013; Paton, 2008; Solberg et al., 2010; Bradford et al., 2012; O’Sullivan et al., 2012; Birkholz et al., 2014; Shen, 2009).

Recognized as an increasingly important area in social sciences, there is an extensive literature on risk perception. However, research studies focusing on risk perception in the context of natural hazards is comparatively less. The literature is particularly meager concerning how risk perception concepts can be employed for increasing disaster resilience of societies (Wachinger & Renn, 2010). That hazard risk perception varies largely among individuals and social groups (Slovic & Weber, 2002; Breakwell, 2010; Twigg, 2013) makes community risk perception a necessary focus for relevant research (Twigger-Ross, 2006).

The concept of risk perception can be approached in several ways. In their study, Birkholz et al. (2014) provides a very clear summary in a table form. The main approaches considered in this summary are: revealed preferences, psychometric paradigm, heuristics & judgement, cultural theory of risk, and social construction of risk. It is apparent from this summary that there have been different approaches suggested in the past 40 years, each based on different focuses and arguments but all examining the basic concept of risk perception.

People’s perception of risk can be studied from different perspectives and based on different aspects. In his book, Renn (2008) approaches these factors under two categories: personal manifestations and collective influences. He further distinguishes four context levels of risk perception among these factors: cultural background, social-political institutions, cognitive-affective factors, and heuristics of information processing (Figure 4). In line with this framework, Breakwell (2010) focuses on personality, cognitive style, beliefs and experience as the individual difference factors while highlighting the importance of group factors such as nationality, socio-demographic characteristics, and belonging to an expert profession. Birkmann et al. (2012a) lists the factors influencing and determining risk perceptions and the decision making as: (1) interpretation of danger, understanding and knowledge of the cause, (2) proximity, exposure, direct personal threat, personal experiences with notable recent serious consequences; (3) people’s priorities; (4) experimental factors; (5) environmental values.

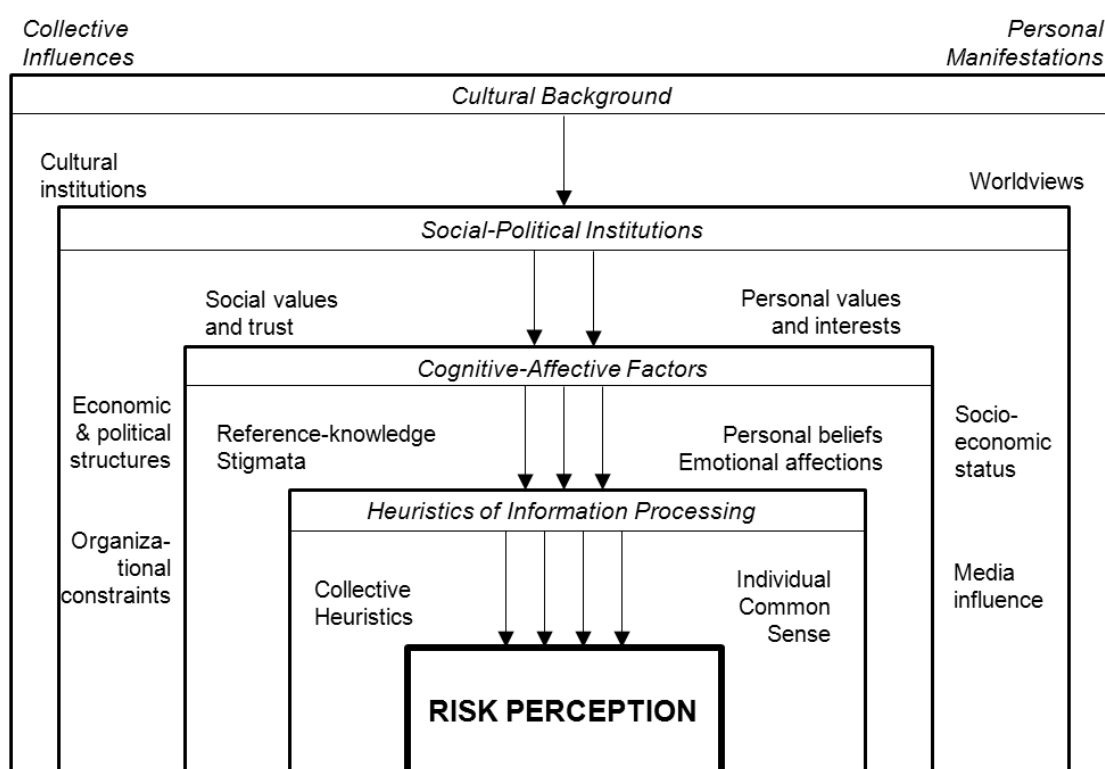


Fig. 4. Four context levels of risk perception (Adapted from Renn, 2008).

“Social perceptions of risk that shape risk behaviour have been studied from different perspectives, e.g. history, sociology and psychology of risk, economics and political science. Lately, risk perceptions in the context of climate change and their influence on social responses to climate-change associated hazards have been a popular research topic as well (Wachinger & Renn, 2010). Being the first primarily social-science project on natural hazards funded by the European Commission, the project CapHaz-Net (Social Capacity Building for Natural Hazards -Toward More Resilient Societies) focuses on risk perception within the scope of natural hazards. The report prepared for CapHaz-Net’s Work Package 3 (D3.1 – Wachinger & Renn, 2010) provides a comprehensive review on risk perception concept in general and discusses the related literature in the context of natural hazards and disasters. Annex A of the report briefly summarizes studies on risk perception of natural hazards in Europe. Similarly, Annex B shows a list of research activities and practices. (It should be noted that

none of these efforts -reported till 2010- involve any tsunami related work done.) The report refers to the following problems:

- *Differences in risk perception between experts and non-experts*
- *Factors altering perceptions of probability in risk contexts*
- *Perception of time scales in environmental processes*
- *Perception of jumps, extreme events, and delay effects*
- *Perception of complexity*
- *Perception of uncertainty*
- *Ambiguity*
- *Amplification and attenuation of risks*
- *Trust*

Having a significant role in community preparedness, the risk perception perspective is intended to improve our understanding about the factors and beliefs that influence the thinking and judgement of people about natural hazards. Thereby, risk perception contributes to people's decision-making about whether or not to prepare for disasters (Johnston et al., 2013). There has been substantial research investigating possible effects of people's general risk knowledge on the degree it prompts mitigative actions against a particular disaster (see, e.g. Lindell & Prater, 2002; Mulilis & Duval, 1995; Martin, Martin & Kent, 2009; Gaillard et al., 2008; Adger et al. 2005). As for the risks associated to natural hazards, the validity of the assumption that risk perception leads to protective behaviours of individuals and/or communities is limited. In fact, risk perception is often not linked directly with preparedness – there are a variety of factors (individual, social psychological and community) strengthening or lessening preparedness behaviour (Johnston et al., 2013; Lavigne et al., 2008). With regard to earthquake risk perception and adoption of risk reduction strategies, Solberg et al. (2010) provides an extensive review of the literature. Among the factors discussed (psychological factors, prior earthquake experience, psychological biases, social factors, material risk factors), he puts a special emphasis on the crucial role of cultural and normative influences in disaster risk reduction planning as a means to enhance people's seismic hazard adjustments. In the context of volcanic hazards, Lavigne et al. (2008) discusses Indonesian people's (short-term preparedness) behaviour based on three factors: risk perception, cultural beliefs and socio-economic constraints. They highlight the difficulty arising due to the social changes inherent within societies through which people's risk perception (thus their vulnerability) evolves.

In the next section, preparedness will be discussed.

1.4. Preparedness

The role of preparedness to potential disasters is undeniably vital for community resilience in disaster prone areas. The impacts and consequences of natural hazards, which are unpredictable and uncontrollable by nature, can be alleviated to a certain extent through mitigation and preparedness activities. Unfortunately, majority of research seems to assume that preparedness actions will reduce human and material loss, and suffering is significantly reduced in communities employing measures of mitigation and preparedness (although it has not yet been definitely reported that there occurs such reduction). However, the role of preparedness is still widely recognized among the countries continually suffering from disasters (see, e.g. Koerth et al., 2013a).

The United Nations International Strategy for Disaster Reduction defines preparedness as *“the knowledge and capacities developed by governments, professional response and recovery*

organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions” (UNISDR, 2009, p. 21).

Overall preparedness of a community to a particular disaster should be founded on a thorough understanding of associated risk, and address all aspects of mitigation, response and recovery. For instance, in case of a tsunami, the outcome of an efficiently designed early warning system can prove valuable to the community in that people can evacuate the region or at least go to higher elevations (i.e. vertical evacuation) to avoid the destruction of tsunami waves to their lives. It is also important that all measures of preparedness be supported by governmental, institutional and private agents both financially and socially. Moreover, necessary formal and legal regulations must be introduced so that preparedness measures can be implemented effectively, particularly in the local context. Some examples of preparedness activities common to most disasters are emergency planning, preparation of educational training programs, maintaining effective and trusted information and communication resources, evacuation planning, and stockpiling of equipment and supplies. These preparedness activities are rather traditional and mostly based on technical aspects. However, it is noteworthy to mention that such preparedness measures might not lead to desirable outcomes. Often neglected is the fact that it is the involvement of people within a community which influences effectiveness of preparedness activities and measures. Actually, it is a matter of question whether people really engage in preparedness and mitigation behaviours. People living in areas prone to natural hazards often fail to act, or do very little, to lessen the risk of death, injury, or property damage (Peek & Mileti, 2002). There are psychological as well as social factors that lead to lack of preparedness behaviour in individuals and communities – for a comprehensive review of the literature, see e.g. Solberg et al. (2010). Hence, an improved level of preparedness can be achieved by considering also the behavioural aspects involved in community preparedness. From this point of view it becomes important to enhance *“the degree to which knowledge and awareness translate into preparedness behaviour”* (Johnston et al., 2005). Consequently, identifying factors facilitating preparedness behaviour of people (both at individual and community levels) has emerged as a major focus of research in the recent past.

The significance of the involvement of the local community members and community groups in the necessary mitigation and preparedness behaviours (during all phases of disaster risk management) has been largely emphasized in the literature as one central requirement for successful and effective disaster management (Basolo et al., 2009; Burningham, Fielding & Thrush, 2008; Karanci, 2013; Karanci & Aksit, 2000; Pearce, 2003; Solberg et al., 2010; Perry & Lindell, 2003). Community resilience can be enhanced if mitigation and preparedness behaviours and collaboration of local communities with disaster risk management agencies are facilitated. The fundamental goals in the efforts to raise community involvement are to reinforce individuals’ intent to help themselves or others and to engage people in structural and non-structural measures to reduce vulnerability. Thereby the capacity of communities for building a culture of resilience can be increased.

For effective mitigation and preparedness behaviours firstly the community members should become aware of natural hazards and their vulnerabilities in case such events occur. In this regard, increasing awareness of individual community members by providing information through various sources such as training programs and brochures is important. However, it has been reported that awareness and information do not automatically lead to preparedness behaviours (Karanci, Aksit & Dirik, 2005; Paton, 2008; Paton et al., 2005). Therefore, it is important to understand the factors that

motivate individuals to take action for mitigation and preparedness, as well as factors that hinder such initiatives (see, e.g. Koerth, Vafeidis, Hinkel & Sterr, 2013). As outlined in “Indicators of community resilience” section of this report, various models attempting to account for variables related to preparedness behaviours suggest that risk/threat appraisals, evaluations of the possibility and methods of coping, responsibility for taking action and actually having skills to cope are important in facilitating responsible behaviour. On the other hand, psychological factors like denial, fatalism, and avoidance hinder such behaviours. All these variables need to be focused upon risk communications and risk management programs for the public (Paton, 2010, 2012; Karanci, 2013).

There are certain issues that need to be considered in facilitating community participation. First and foremost, diverse measures for all hazards need to be taken. Secondly, community participation and ownership is essential. However, the task of facilitating community members to act is a challenging area for the reason that there are complex relationships between hazard effects and community characteristics; and between preparedness and risk perception. Also, heterogeneity in community characteristics and in perceptual processes (Paton & Johnston, 2001) further complicates the situation. Therefore, interventions at individual and community levels must be explored, and the role of cultural factors (individualistic vs. collectivistic cultures) as well as development level of countries/communities needs to be acknowledged in efforts to facilitate preparedness. Last but not the least, establishing sustainability is a crucial task for such efforts to be successful in the long term.

The explanations given above are mostly general statements and valid in a broad context in disaster research. It is worthwhile mentioning that most of the attention in the literature is devoted to understanding and analysing preparedness largely for earthquakes and (river, coastal, flash) floods. However, far too little attention has been paid to tsunami preparedness. For example, there are very few journal articles and technical reports on community preparedness for tsunami hazard in the United States (Lindell & Prater, 2010).

Considering the subtasks of WP9.1, the next section of the report introduces the concept of tsunami resilience and describes characteristics of tsunami resilient societies. Next, the existing work on (1) preparedness skills and attitudes for facing tsunami hazard, (2) accessibility mapping and evacuation simulations, (3) tsunami crisis management, (4) tools dedicated to tsunami awareness and preparedness are reviewed in the light of the introductory information provided in this chapter.

CHAPTER 2 TSUNAMI RESILIENT COMMUNITIES

The concept of tsunami resilience has been around only since late 1990s. For instance, Bernard (1999) defined tsunami-resistant communities as communities able to produce tsunami hazard maps, implement and maintain education, and develop early warning systems. Within the framework of the National Tsunami Hazard Mitigation Programme (NTHMP, established in 1996) of America, five goals identified for the mitigation projects that would advance the development of tsunami-resilient communities are given as follows: tsunami resilient communities should: (1) understand the nature of the tsunami hazard, (2) have the tools they need to mitigate the tsunami risk, (3) disseminate information about the tsunami hazard, (4) exchange information with other at-risk areas, and (5) institutionalize planning for a tsunami disaster (Dengler, 1998). An enriched definition of a tsunami-resilient community is provided by Jonientz-Triesler et al. (2005): these communities “*may suffer some inevitable damage, but will have planned, exercised, and educated its citizens and its leaders in ways to save lives, protected as much property as possible, tried to ensure safe location for critical functions the community needs, and will use lessons from a tsunami event suffered by their community or other communities to improve their level of resilience for future events*”. Gaillard (2007) adds that these communities “*are able to overcome the damages brought by the occurrence of natural hazards, either through maintaining their pre-disaster social fabric, or through accepting marginal or larger change in order to survive*”, therefore, the concept of change is closely related to the concept of resilience in that post-disaster changes occur within the impacted society. These changes can be, for instance, technological, economic (e.g. availability of resources), behavioural (e.g. preparedness, risk awareness), social or cultural in nature (based on Morin et al., 2008).

Characteristics of tsunami resilient societies can be identified based on their technical, social and institutional/governmental capacities to cope with a future tsunami, which as a whole determines the level of preparedness. An information guide on tsunami preparedness is provided by Intergovernmental Oceanographic Commission of UNESCO (IOC Manuals and Guides No. 49, 2008). In this document, there are five steps identified for tsunami preparedness: (1) background research, (2) designing a theoretical tsunami, (3) estimating tsunami damage, (4) preparedness tasks, (5) setting up a tsunami hazard mitigation plan (Fig. 5).

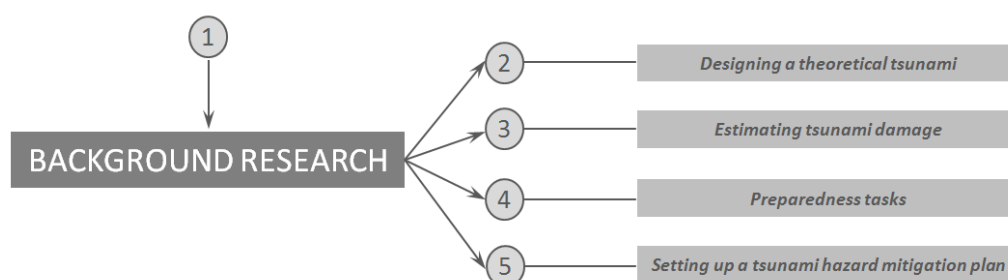


Fig. 5. Five steps towards tsunami preparedness (Adapted from IOC Manuals and Guides No. 49, 2008).

A society’s resilience to tsunami largely depends on its preparedness level. However, such preparedness is commonly meant to refer to technical aspects involved – e.g. establishing structural measures (e.g. seawalls, tsunami breakwaters, tsunami-resistant buildings) and hazard-risk assessment studies (e.g. tsunami detection and forecasting, tsunami modelling, hazard mapping).

Table 2 lists various elements of measures and practices aimed at building tsunami resilient societies.

Table 2. Requirements of tsunami resilient societies (Adapted from IBRD/World Bank, 2012).

Structural measures	<ul style="list-style-type: none"> • Seawalls, tsunami breakwaters, tsunami control forest belts • Tsunami resistant buildings • Assessment of building performances • Rehabilitation of hydro-meteorological disasters(associated with tsunamis and earthquakes)-prevention structures • Multifunctional structures • Protecting significant and sensitive facilities
Non-structural measures	<ul style="list-style-type: none"> • Community-based disaster risk management • Disaster management plans • The education sector • Business continuity plans • Tsunami (and earthquake) early warning systems • Evacuation planning • Land-use strategies for urban planning, land use regulation, and relocation • Coastal risk management
Emergency response	<ul style="list-style-type: none"> • Mobilizing and coordinating expert teams, nongovernmental organizations, nonprofit organizations, and volunteers • Emergency communication • Logistic chain management for emergency supplies • Supporting and empowering municipal functions and staff • Evacuation centre management • Ensuring protection in response and equity in recovery
Recovery planning	<ul style="list-style-type: none"> • Infrastructure rehabilitation • Reconstruction policy and planning • Transitional shelter • Debris management • Livelihood and job creation
Hazard and risk information and decision making	<ul style="list-style-type: none"> • Tsunami detection and forecasting • Tsunami modelling • Tsunami hazard mapping • Vulnerability and risk assessment • Risk and damage information management • Risk communication
Economics of disaster risk, risk management, and risk financing	<ul style="list-style-type: none"> • Measuring the cost-effectiveness of various disaster risk management measures • Earthquake risk insurance • Assessment of economic, financial, and fiscal impacts of tsunami • Strategies for managing low-probability, high-impact events

Essentially, all these efforts – concerning mostly engineers and scientists – must be complemented with necessary arrangements for both planning and implementation phases, e.g. through establishment of efficient Institutional and organizational frameworks within the local context as well as on a regional scale. It is also important that there be effective warning and communication systems in support of well-functioning organizational structures involved in disaster management authorities. Lastly, yet most importantly, it is the education and preparedness of individuals and communities (rather than implementation of solely technical elements) that determine how resilient the societies are against a potential tsunami in future. In this respect, promoting public awareness,

and education of at-risk individuals are the key practices that can increase the efficiency and effectiveness of aforementioned efforts to build tsunami resilient societies. (The tools used for this purpose are exemplified in the last part of this section.) The launch of such key practices necessitates consideration of certain social aspects for research. For example, factors enhancing/hindering psychological preparedness of individuals and communities must be assessed, and their risk perception needs to be investigated. The main objective behind these research and analysis is to increase the effectiveness of tsunami hazard education and public participation in mitigation measures. Consideration of various sociological dimensions of socioeconomic vulnerability is moreover crucial to understand differences in vulnerability for the social groups, and to formulate effective tsunami risk prevention policies. Duzgun et al. (2011) identifies these dimensions in respect of individuals'/communities' characteristics – which are (i) socio-demographic, (ii) socio-economic, (iii) social security, (iv) socio-spatial, (v) political, and (vi) behavioural. Within the scope of these sociological dimensions, socio-spatial dimension is of greater prominence and influence in communities' resilience to tsunamis in at-risk areas. On the whole, requirements of tsunami resilient societies should be discussed in view of certain aspects covering various social dimensions also. Accordingly, Table 3 summarizes the social aspects involved in building tsunami resilient societies.

Table 3. Social dimensions of building tsunami resilient societies.

<i>Social elements</i>
<ul style="list-style-type: none"> • Creating tsunami planning strategies • Establishing institutional framework for tsunami disaster management • Increasing stakeholder participation • Providing effective risk communication (e.g. tsunami warning) • Raising tsunami awareness, e.g. through public education • Analysis of preparedness behaviour of individuals and communities • Consideration of socioeconomic vulnerability of communities

In the light of above discussion, the efforts by the Intergovernmental Oceanographic Commission of UNESCO is worthwhile mentioning. For example, in the report “Tsunami Preparedness Civil Protection - Good Practices Guide” by the NEAM Tsunami Information Centre (IOC/UNESCO, 2013) a group of guidelines is summarized and proposed to help civil protection authorities and coastal communities understand their exposure to tsunami hazards and to mitigate the resulting risk through awareness, preparedness information and land use planning. Strategic approaches are also proposed for a more effective development of tsunami risk awareness campaigns. In another report called “Hazard Awareness and Risk Mitigation in Integrated Coastal Management (ICAM)” (IOC/UNESCO, 2009) guidelines addressing inadequate awareness, planning and coordination in both national and local authorities and agencies (e.g., lack of warning through poor regional detection and communication systems.) are provided to help creating increased resilience to hazard events most importantly by promoting the institutional capacity for emergency preparedness and response.

The knowledge notes (grouped into six thematic clusters) from the Learning from Megadisasters Project of the Government of Japan and the World Bank Group is yet another highly beneficial document aimed at sharing experiences from the Great East Japan Earthquake of 2011. The notes (available through <http://wbi.worldbank.org/wbi/megadisasters>) - clustered in various themes, particularly offer recommendations for developing countries that face similar risks and vulnerabilities (IBRD/World Bank, 2012).

Tsunamis, by nature, incorporate several aspects of earthquakes (e.g. source mechanism) along with those of floods (e.g. inundation of land). Having such similarities, certain research findings and practices on earthquake as well as flood resilience (with regard to non-structural measures and social elements of disaster resilience) can be well applicable for tsunami resilience too (for instance, evacuation planning strategies, barriers and facilitators of involvement in preparedness). Yet, the existent particularities of tsunami as a natural hazard with respect to earthquakes and floods necessitates individual research and practices solely on tsunami preparedness. As for example, tsunami is not as a common disaster as floods and earthquakes, thus is less known by the public. Such unfamiliarity to tsunami can definitely have influences on individuals and communities' risk perception, thus on their preparedness level. In terms of natural warning signs, while flooding of a river is expected because it usually occurs as a result of heavy precipitation events that last over longer durations (few days or even weeks) tsunamis are rather unexpected. One of the most common sign of a potential tsunami is occurrence of an earthquake. The time available between the occurrence of an earthquake and the following tsunami might differ depending on proximity of the area of concern to earthquake epicentre (i.e. locally generated vs. regional/distant generated tsunami). However, the available time usually changes between a couple of minutes (at minimum) and to a day (at maximum). Roaring of the ocean/sea is another natural phenomenon which indicates a sign for a potential tsunami –however there is not that much time available between the sign and the occurrence of tsunami. On the whole, in terms of time availability, evacuation planning is more challenging for tsunamis than for river floods. This situation raises the importance of early warning systems for tsunamis, as well as of understanding evacuation behaviour of individuals. In this respect, there are certain behavioural aspects of preparedness and risk perception which need to be studied specifically for tsunamis within the scope of social disaster research. For instance:

- Are there any more barriers and facilitators of involvement in preparedness different than those identified for earthquakes and floods? Is there any only tsunami specific factors triggering preparedness?
- What are the effects of different tsunami characteristics and origin of tsunami on communities' response behaviour (e.g. evacuation, preparedness)?
- What can be done to increase awareness to tsunami disaster and preparedness at behavioural level?
- What is the most appropriate medium (mobile, TV, radio, etc.) for communicating tsunami warning? What is the minimum duration for people to evacuate?
- Does the role of community participation and ownership differ between tsunamis and earthquakes (and floods)?
- What are the outcomes of the efforts (e.g., education methods) done to date? What are the assessment methods?

Most studies in the field of resilience (within natural hazards and disaster risk reduction context) have only focussed largely on earthquakes and (river) floods, and, to a lesser extent, on sea-level rise, typhoons, etc. There are a number of studies focusing on resilience of coastal communities to tsunami (and other coastal natural hazards) with regard to both engineering and social science aspects. However, the emphasis of the literature is to a great extent on technical elements listed in Table 2. For instance, there is a large volume of published studies on tsunami hazard modelling, through which hazard maps can be produced to form a base for tsunami evacuation plans. In the context of social science aspects of community resilience, however, there were only a number of

studies solely on tsunamis, particularly related to understanding and assessing community resilience to coastal hazards in general. Here these are briefly mentioned:

Regarding aforementioned socio-spatial dimension, the study of Kafle (2012) – where a tool for measuring community resilience capabilities using process and outcome indicators in 43 coastal communities in Indonesia – concludes that community resilience needs to be measured and analysed separately for different locations, and specific to different hazard types. The reasoning behind such conclusion is obviously the existence of many regional differences within communities regarding the indicators used. Such socio-spatial differences are naturally reflected in a disaster's consequences. For example, it is stated in the report by IOC/UNESCO (2013) that the preparedness of the local communities and the response of civil protection authorities in the recent tsunami events of 26th December 2004 (Indian Ocean) and the 11th of March 2011 (Japan) were highly influential in that the consequences in terms of human lives showed a strong contrast for different local communities. The effect of geographic levels considered in resilience studies is another issue that needs attention. In her MSc thesis, Li (2013) investigates the effect of studying resilience measurements at two geographic scales. Community resilience to coastal hazards (including coastal flooding, hurricane/tropical storm, tornado, and severe storm/thunder storm) in Louisiana is analysed using a model called the Resilience Inference Measurement (RIM). It was found that there was consistency in the results obtained at the two geographical levels.

Evaluation of capacities and adaptive mechanisms for natural disasters is a major area which is getting increasingly more attention recently. For instance, Rahman & Kausel (2013) examines planning and social capacity to evaluate community resilience of the Dichato community, one of the most affected communities by the 27 February 2010 earthquake and following tsunami in central Chile. The elements of resilience considered for the analysis of qualitative data are governance, society and economy, resource management, land use and structural design, risk knowledge, warning and evacuation, emergency response, and disaster recovery. The results obtained in the study is expected to help enhancing disaster preparedness in community level for coastal communities like Dichato where tsunami hazard risks are not well addressed and considered in plans and programs. Another example study is provided by Reams, Lam & Baker (2012). They developed an index of community capacity for resilience for coastal counties of the U.S. Northern Gulf of Mexico region based on the modified version of the index of social vulnerability to environmental hazards (SoVI) in Cutter, Boruff & Shirley (2003). By combining variables indicating the capacity for adaptability or resilience (e.g. financial resources and public investment patterns of local governments, land elevation, and citizen involvement in public affairs), a useful approach for the more systematic examination and comparison of exposure, vulnerability and capacity for resilience among coastal communities is demonstrated for each of the 52 coastal counties of Louisiana, Texas, Mississippi, Alabama and Florida.

Other studies on few other social science aspects of community resilience are as follows: Rumbach & Foley (2014) discusses the role of indigenous (local) institutions in disaster risk reduction and resilience, which is definitely essential, based on the findings from the 2009 Tsunami in American Samoa. Pooley, Cohen & O'Connor (2006) on the other hand points out the links between community and individual resilience by considering their effects on vulnerability and post-disaster outcomes on a case study from Northwest Australia, a region where the community suffers from cyclones.

The further literature specifically on tsunamis in respect to the topics identified within the subtasks of WP 9.1 under the theme “building tsunami resilient societies” are summarized in the following sections.

2.1. Review on existing work on preparedness skills, and attitudes facing tsunami hazard

In the face of tsunami threat, people generally behave according to hazard-related factors (hazard knowledge, risk perception, authorities recommendations and credibility, etc.) but also often according to non-hazard-related structural factors (food security, livelihoods, poverty, attachment to place, cultural beliefs, etc.). These factors underpin people's vulnerability and capabilities as well as community resilience in facing tsunami hazard. Tsunami risk and disaster management plans, when they exist, often overlook these factors, especially non-hazard related factors. Therefore, it is of crucial importance to understand why and how people live in areas threatened by tsunami hazard to come up with a profile of endangered communities. This profile shall enable to assess people's vulnerability and capabilities as well as community resilience.

Most of the attention in the literature is devoted to understand and analyse preparedness for other natural hazards (largely for earthquakes and various type of floods). However, far too little attention has been paid to tsunami risk perception and preparedness. For example, there are very few journal articles and technical reports on community preparedness for tsunami hazard in the United States (Lindell & Prater, 2010). Although it can be assumed that research findings on risk perception and preparedness for other natural hazards is applicable in a broad context in disaster research, the validity of these findings for tsunamis can be limited, thus should be treated with caution.

There are some articles and studies, especially in the recent years, which have focused specifically on tsunamis. Here, these articles and studies are listed and main findings and conclusions are shortly summarized:

Being an important indicator of community resilience (as explained in the first section), tsunami studies on risk perception are fundamental to the scope of literature reviewed as a part of this report. In fact many of the existing studies on tsunami resilience within social sciences predominantly focus on individuals' risk perception on tsunami hazard. For example, Guastello et al. (2008) develops a generalizable cusp catastrophe model that is capable of reflecting the dynamics of risk perception and decision-making through consideration of social comparison, persuasive arguments, information certainty, and the decision-makers' ability to interpret the visual cues within its parameters. Drawing from existing catastrophe models for the approach-avoidance conflicts and the perception of ambiguous stimuli, the proposed theoretical model reckons on the principles from the social psychology of group dynamics as well. Based mainly on the behaviour of spectators at the scene of the 2004 Indian Ocean tsunami, the model suggests that raising public awareness on tsunami hazard and associated preparedness activities is essential. Besides, public communication should be particularly made prior to the tsunami event itself, and should be tailored to different groups separately. Indeed, risk perception may very well differ depending on a variety of factors, including socio-economic, cultural, and environmental conditions; and demographic differences. In their study, Kurita, Arakida & Colombage (2007) identifies the regional differences in tsunami risk perceptions of people in three countries (Indonesia, Sri Lanka, and the Maldives) affected by the

2004 Indian Ocean tsunami. The results from this comparative analysis based on sociocultural backgrounds and geographical settings of each country elicited certain differences in people's behaviour and judgment adjustments as well as common traits. For example, a lack of priori knowledge on tsunamis prevails in residents of all three countries. However, there were differences in their outcome expectancy beliefs in terms of whether such knowledge would reduce the damage occurred.

Hazard awareness and perception of tsunami risk are crucial aspects determining behaviour of people as an immediate response; for instance, evacuation – one of the fundamental components of tsunami risk management. Effective response to tsunami warnings is expected highly to depend on hazard education as well as many other factors associated to people's (tsunami) risk perception. It has been reported in the literature that different ethnic groups' response to natural hazards varies significantly at different stages of disaster management. Considering the fact that most of the coastal communities around the world are ethnically diverse, display of differences in people's response to tsunamis (and earthquakes) is rather prospective. This is confirmed by Gaillard et al. (2008) for the province of Aceh in Indonesia. Drawing upon on a contextual framework of analysis based on the cultural, social, economic and political factors influencing people's behaviour, they found that the existence (or absence) of disaster subculture within the communities of Aceh, Indonesia further justifies differences in victims' behaviour in response to the 2004 Indian Ocean tsunami. It is added that such differences are also supported by the level of people's capacity to protect themselves against the tsunami.

In their study discussing public perceptions of tsunami hazard and risk in Sydney (Australia), Bird & Dominey-Howes (2008) tested a questionnaire survey designed specifically to gather useful information for emergency management agencies to develop tsunami education campaigns and risk mitigation strategies in Australia. They reported that there was significant confusion and misunderstanding related to tsunami warning alert messages issued after the April 2007 tsunami. Fraser, Leonard & Johnston (2013) investigated hazard awareness and intended evacuation behaviour in a hypothetical local earthquake and tsunami in Napier, New Zealand. The results of the survey suggest high levels of tsunami hazard awareness, yet as well with confusion around warning expectations, which is a pertinent finding in view of several observations of previous surveys, including Bird & Dominey-Howes (2008). Analysis of the evacuation behaviours shows further consistency with international literature on evacuation behaviour. It was also demonstrated that demographic factors are influential in decision-making. However, it should be noted that these findings are based on a hypothetical tsunami scenario and there well might be differences for evacuation behaviours observed in an actual event. Both of these studies highlight the importance of conducting such surveys for understanding their beneficial implications on tsunami hazard education programmes.

An interesting study by Västfjäll, Peters & Slovic (2008) investigates whether affect elicited by thinking about a recent major tsunami disaster (the 2004 Indian Ocean tsunami) influenced risk perceptions and future pessimistic/optimistic thinking among Swedish undergraduates not directly affected by the tsunami. It was found that *“the negative affect elicited by thinking about a recent major natural disaster leads to a more pessimistic view of the future”*.

Further studies deal mostly with the relation between risk perception and preparedness. For instance, past experiences (i.e. familiarity) with tsunamis can potentially impact individuals' perception of risk thereby can have certain indications on their level of preparedness. That unfamiliarity with tsunami hazard can lead to low perception of associated risk, hence low levels of preparedness is confirmed for Tasmania – one of the Australian communities under tsunami threat – through a recent study by Paton, Frandsen & Johnston (2010). They also discuss the applicability of a model which was successfully applied for predicting tsunami preparedness in the United States. The Tasmania case study showed that preparedness couldn't be predicted reliably by this model particularly for tsunamis, a hazard with low risk acceptance. The importance of past experience of a tsunami is further emphasized by Rachmalia, Hatthakit & Chaowalit (2011). In their study, they conducted a descriptive comparative analysis of tsunami preparedness among people living in affected and not-affected areas of Aceh, Indonesia by the 2004 Indian Ocean tsunami. The level of tsunami disaster preparedness is assessed at individual level based on three parameters: (i) knowledge, (ii) individual emergency planning, and (ii) resources mobilization capacity. While the level of people's preparedness is found to be moderate for both areas, major differences prevail in mean scores of each parameter, indicating the significance of direct and indirect tsunami experience in people's preparedness to tsunamis. It was also concluded that preparedness levels were not at maximum in non-affected areas despite the increased awareness level of people. A similar confirmation is found in a study by Connor (2005). He reported that increased public attention due to the December 26, 2004 Indian Ocean tsunami improved the level of awareness in Seaside Oregon, yet it didn't result in any significant increases in emergency preparedness by households and businesses. On the contrary, Wegscheider et al. (2011) states that there exists increased willingness to undertake preparedness measures in few Indonesian communities for reducing potential tsunami risk following the 2004 Indian Ocean tsunami which resulted in increases awareness of risk. All these studies (except Wegscheider et al., 2011) assert that increased public attention to tsunami hazard and increased prominence of tsunamis on the public agenda does not directly cause increased preparedness of people in coastal communities. This situation hence raises the importance of generating tsunami risk knowledge at community level as a base for planning and implementation of risk reduction strategies. Public education campaigns, for example, are a common implementation. However, the effectiveness of such education does not always guarantee good outcomes, as will be explained in the next paragraph.

Tsunami preparedness of individuals is an important aspect which received much attention in the literature. Paton et al. (2009), without having the intention of replacing existing hazard preparedness models, proposes and tests a model that considers social context characteristics as influencing factors on the levels of people's preparedness along with their personal beliefs regarding tsunami hazards and their mitigation. The social context factors identified are community participation, collective efficacy, empowerment, and trust. While the latter two are important from the perspective of community members' relationship with civic sources of hazard information, the first two factors consider community members' relationship with each other. Based on the hypothesis that trust predicts intentions, and intentions mediate the relationship between trust and preparedness, the model is capable of distinguishing between intention and actual preparedness behaviour. Testing of the model on coastal communities in Alaska and Oregon at tsunami-risk areas has shown promising results for its ability to account for and explain differences in levels of tsunami preparedness. Overall, it is concluded that the model can reliably predict people's preparedness

decisions, thus it can play an important role in shaping outreach strategies and designing programs for tsunami hazard education, and consequently promote tsunami preparedness. In an empirical study by Johnston et al. (2005), preparedness level of residents (including visitors, in total over 300 people) to deal with tsunami hazards along the west coast of Washington State in the U.S. was investigated based on their perceptions of tsunami hazards. The influence of the hazard education program, which was undertaken as a part of the U.S. National Tsunami Hazard Mitigation Program (NTHMP; see e.g. Jonientz-Trisler et al. 2005), on tsunami hazard preparedness was assessed. The results from the surveys, focus groups and school surveys indicate that the hazard education program has been successful in terms of promoting awareness of and access to information about tsunami hazard. However, levels of preparedness were found to be at low to moderate levels. This study emphasizes both the importance of accommodating pre-existing beliefs and interpretive processes, and the need for additional strategies to augment existing programs with initiatives that manage these beliefs and perceptions in ways that facilitate preparedness in Coastal Washington. A report by GNS - a research institute on natural hazards in New Zealand – (Currie, Enjamio, Girardo & Hensel, 2013) assesses the Greater Wellington residents' awareness to and preparedness for a potential earthquake and resulting tsunami. The pilot study covering 400 face-to-face interviews has revealed the confirmation of low tsunami preparedness in the Greater Wellington region. Johnston et al. (2013) discusses community understanding and preparedness with regard to earthquake and tsunami risk in Wellington, New Zealand in the wake of public education campaigns. The results obtained from the evaluation surveys revealed that although levels of risk awareness were high comprehensive preparedness levels were low. Consequently they point out the link between preparedness and risk perception, as well with other psychological and social factors and discuss the implications of such interaction on public education.

Ancestral knowledge can be also expected to play a role in tsunami preparedness. A study by Fritz & Kalligeris (2008) demonstrated that ancestral tsunami heritage motivated self-evacuation behaviour of people causing significantly less fatalities in 2007 Solomon Islands tsunami (which caused more than 6000 houses get damaged or destroyed). That the available time for evacuation was highly short (only few minutes) increases the importance of the findings of this study. Such inherited community-based tsunami information founded on past experiences enables individuals and communities to pass on their familiarity with associated preparedness behaviour to next generations. A similar finding is provided by Gaillard et al. (2008) for the Simeuleuh Island, Aceh (Indonesia) in response to the 2004 Indian Ocean tsunami. Seeing the sea's withdrawal, Simeulue Island inhabitants immediately escaped towards surrounding mountains. Consequently only 44 deaths occurred whilst 178,000 Banda Aceh inhabitants passed away. Simeulue is located west of Sumatra close from the earthquake epicentre. The accounts passed from generation to generation of the deadly 1907 tsunami enabled them to understand what was happening. Simeulue inhabitants even have their own word to name the phenomenon: smong. The 26 December 2004 consequences led the Indonesian government to consider the integration of this word into the official Indonesian language. This helped to increase national awareness of tsunami hazards, all the more so as smong creates a very helpful acronym: SeMua Orang Naik Gunung ("Everybody move up on the hills"). Another evocation of inherited knowledge is reported by Adger et al. (2005) on Surin Island in Thailand where fishing communities, attentive to nature forewarnings, avoided the tsunami. Tilly Smith, a ten-year-old British girl vacationing in Thailand, interpreted the receding of water as a forewarning sign of the impending tsunami, remembering her geography lessons at school. Her

warning allowed the evacuation of the beach and surroundings, such that there was no loss of life (<http://portal.unesco.org>). All these findings highlight the significance of community-based education and awareness programs.

It is an inevitable fact that more research is needed regarding preparedness skills, and attitudes facing tsunami hazard. Guiding researchers and practitioners is of great necessity in this respect. A study by Lindell & Prater (2010) addresses research needs that would enhance coastal communities' ability to respond effectively to tsunami threat by employing an evaluation framework based on four principal emergency response functions derived from federal guidance documents: emergency assessment, hazard operations, population protection, and incident management. Thereby, their study has an important role in guiding future research on tsunami emergency preparedness and risk communication, particularly for the Pacific Northwest. For example, it is recommended to the NTHMP to integrate social science research findings from other hazards.

The review summarized in this section focuses mostly human/individual indicators (of tsunami and/or community resilience) with regards to coping skills and behaviour (i.e. preparedness); cognition and knowledge (i.e. awareness, risk perception); and demographic settings. However, it is of interest to note that the present literature on preparedness skills, and attitudes facing tsunami hazard is sparse. Moreover, the concentration is most particularly on the Pacific & Indian region. Overall, it is also clear that the present literature definitely lacks a comprehensive and integrated understanding of the effects of various sociological dimensions (socio-demographic, socio-economic, social security, socio-spatial, political, and behavioural) on preparedness skills, and attitudes facing tsunami hazard.

2.2. Review on existing work on tsunami crisis management

Crisis management is one of the fundamental aspects of disaster management cycle. A comprehensive and efficient crisis management can indeed prevent excessive loss of life and reduce the disaster impacts. A disaster management cycle with special reference to tsunamis is provided in Figure 6. In this figure, the components "response", "short term relief", "post-disaster assessment and mitigation", and "relief and recovery" are central to the scope of tsunami crisis management. While "response" puts special emphasis on measures like early warning and evacuation, "short term relief" includes measures complementing "response" activities, e.g. provision of evacuation centres and temporary housing, basic health services, and food. "Post-disaster assessment and mitigation" on the other hand is another major component crucial for reducing the potential tsunami risk in the future. Lastly, "relief and recovery" is aimed at helping people to recover from the tsunami disaster and continue their routine life. The role of local government, national government, international bodies, private sector, media, and scientific community as well as communities is all equally important for a successful tsunami crisis management.

Both the academic and the grey literature are rather weak at analysing tsunami crisis management from the aspects just explained. Next, various articles, studies and reports found in the literature are shortly explained.

The role of learning from past experiences of tsunami disaster is of great importance for improving tsunami crisis management for a future tsunami from both functional and operational aspects. The

report by IOC/UNESCO (2008) – where the focus of the report is mainly on early warnings and evacuation strategies – summarizes the lessons learned from Indonesian tsunamis in 2004 and 2006 (Aceh and Pangandaran, respectively) based on the experiences of eyewitnesses. Referring to the experiences from the Great East Japan Earthquake of 2011, the knowledge notes (as mentioned previously in Section 2) by IBRD/World Bank (2012) provides a tremendous source of information on emergency response and recovery planning (Clusters 3 and 4) in the form of recommendations. Within aspects of emergency response, the highlighted issues are (i) mobilization and coordination of expert teams, (ii) nongovernmental organizations, nonprofit organizations, and volunteers, (iii) emergency communication, (iv) logistic chain management for emergency supplies, (v) supporting and empowering municipal functions and staff, (vi) evacuation centre management, and (vii) ensuring protection in response and equity in recovery. In terms of recovery planning, the points of necessity are identified as (i) infrastructure rehabilitation, (ii) reconstruction policy and planning, (iii) transitional shelter, (iv) debris management, and (v) livelihood and job creation.

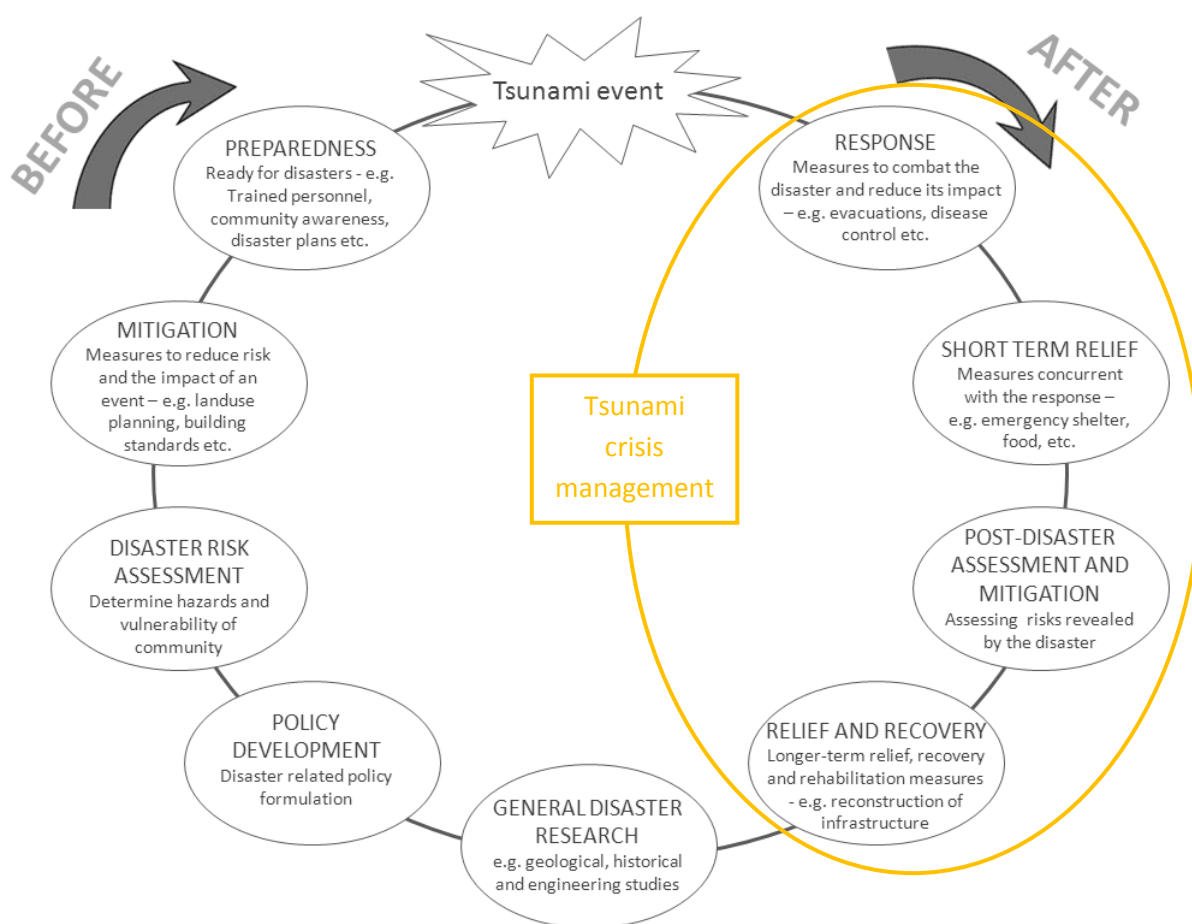


Fig. 6. Key elements of the disaster management cycle (with special reference to tsunami)
(Adapted from Bird & Dominey-Howes, 2008).

In point of fact, each tsunami disaster is an opportunity for communities, and authorities responsible for emergency/response activities to identify their incompetence regarding tsunami crisis management. Accordingly, they can enhance their ability to cope with tsunamis. This requires a detailed assessment of post-disaster activities. Conducting post-disaster surveys is a worthy way of gaining such information for improving both the functional and operational aspects of existing

system of tsunami crisis management in general. A post-disaster research can utilise various methodological techniques such as video interviewing and questionnaire surveys. A post-tsunami survey field guide is provided by the International Tsunami Survey Team (ITST) of IOC/UNESCO (Dominey-Howes et al., 2012) which covers principles, protocols, and a set of best practices and templates for post-tsunami surveys. Various issues regarding *before*, *during* and *after* the survey are also highlighted. (A review of current knowledge and practice on the use of questionnaires for obtaining information of public perception of natural hazards and risk mitigation is given by Bird, 2009) Bird, Chagué-Goff & Gero (2011) reviews three post-tsunami disaster case studies: the 2004 Indian Ocean tsunami (using primarily video interviews), the 2006 Java tsunami (using primarily video interviews), and the 2009 South Pacific tsunami (using primarily questionnaire interviews). By investigating survivors' behaviour before, during and after the tsunami disasters through the data generated from these interviews, they analyse the complexities affecting public response on which they base their recommendations for facilitating improved community-based disaster risk reduction strategies (e.g. tsunami education programmes) in Australia. Sahal & Morin (2012) presents the results from the post-tsunami survey conducted in La Re'union Island following the October 2010 earthquake and tsunami in Indonesia. The findings from the survey provide indicate that the event management by the local authorities was not successful due to their lack of action – pointing especially to the weaknesses of the local early warning system and protocols.

In investigations and assessments of tsunami crisis management capabilities, consideration of well-established frameworks is important. Post et al. (2009) proposes a methodological framework for assessing human immediate response capability (in terms of time) related to tsunami threats in Indonesia at a sub-national scale. They identify the estimated time of arrival of a tsunami, the time at which technical or natural warning signs can be received by the population, the reaction time of the population, and the evacuation time as the key factors determining human response. Quantification of the evacuation time considers *human extrinsic (land cover, topography, population density) and intrinsic factors (age, gender distribution) by assigning different evacuation speeds properties and evacuation speed reductions*. The results are obtained for the coastal areas of Sumatra, Java and Bali and give indication for hotspots of weak response capabilities and estimation of evacuation times. As such, the findings of the study provide prioritization strategies for early warning, evacuation and contingency planning as well as for awareness and preparedness particularly in terms of local level tsunami response.

Human immediate response capacity to tsunamis is very much influenced by the characteristics of vulnerable populations as well. Identification of these characteristics is important in that recovery measures (e.g. disaster relief) should take into account the differences in vulnerability within the tsunami-affected areas. The study by Nishikiori et al. (2006) is a good example within this line of research. Conducting a cross-sectional household survey in 13 evacuation camps for the (internally) displaced Sri Lanka population affected by the 2004 Indian Ocean tsunami, they analysed the risk factors of mortality. The characteristics of study sample are studied in two levels: individual (sex, location when tsunami hit, pre-existing health problem, status of survival) and household level (living area, ethnicity, educational level, occupation of householder, household income, house destruction). Among the displaced population, the highest mortality rate was found to be in women and children. Accordingly, directing relief and recovery activities to this vulnerable group for the next time can ensure more focussed, relevant, and efficient tsunami crisis management.

Emergency response planning is a crucial aspect among various other aspects (see, e.g. Figure 6) involved in tsunami crisis management. Generation of a valid emergency response plan is the first step. An emergency response plan should include (i) warning notification protocols and systems; (ii) evaluation and mapping of evacuation routes, with signage to designated assembly points; (iii) consideration of evacuation timing; and (iv) staff training and evacuation plan exercising (Garside et al., 2009). Followed by the implementation (and dissemination), the plan should be integrated and maintained in the long-term. Accordingly, collaboration and cooperation between the authorities/offices/agencies responsible for tsunami crisis management is of fundamental necessity for achieving good outcomes. Adoption of a community-based approach in emergency response planning is another key factor which will definitely prove beneficial. A tsunami emergency response plan for a coastal community in Malaysia is developed founded on a community-based disaster preparedness approach by Said, Mahmud & Abas (2011). The work, using the 2004 Indian Ocean Tsunami as a case study, proves the viability of a community-based approach (where the local community is taken as the primary focus of attention in disaster reduction) to tsunami mitigation and preparedness. It is stated that community-based approach to disaster preparedness can enhance community preparedness to tsunami and should be adopted in countries which do not have a tsunami emergency response plan yet.

In the long-term relief practices for tsunami crisis management, provision of psychological support to disaster victims is as well important, and it requires a special emphasis. However, this practice is often neglected especially in developing countries.

Obviously, there is limited literature on tsunami crisis management, and it certainly indicates a lack of attention. Therefore, the field of tsunami crisis management is yet about to be advanced. The aim of related research should be particularly on establishment of comprehensive frameworks for tsunami crisis management, and assessing their effectiveness. Such assessment of course requires a well-defined structure regarding the components of tsunami crisis management.

2.3. Review on existing work on accessibility mapping and evacuation simulations

In this section, accessibility and evacuation as a part of emergency response planning within tsunami crisis management are discussed next.

Accessibility maps and evacuation simulations are necessary tools for efficient and effective disaster crisis management. Tsunami crisis management also requires analyses of accessibility and evacuation models for minimizing the loss of human lives and the total number of affected populations in coastal regions. These tasks are usually more challenging in case of tsunamis due to extensive damage to infrastructures (e.g. mainly road networks) caused by both the earthquake and flooding.

Accessibility

Accessibility of a location is defined as the degree of ease with which the location may be reached from one or several other locations through the use of all or some of the available modes of transport (Bavoux, Beaucire, Chapelon & Zembri, 2005). “The term physical accessibility has long been used by geographers, economists, and urban planners and basically reflects the relative ease of

access to/from several urban/rural services by considering several traveling costs. GIS based accessibility modeling can be an important guide for disaster managers to decrease the amount of affected population, before, during and after disaster. Numerous accessibility measures, ranging from simple to sophisticated, can be found in the GIS-based accessibility modeling literature”. There are various accessibility measures used in the literature. While the simple measures only consider proximity in terms of time and distance, there are also more sophisticated measures taking into account both proximity and availability” (Ertugay & Duzgun, 2011).

Being an essential component of territorial vulnerability, assessment of accessibility in disaster situations has been interest to many researchers from different disciplines. For example, in disaster context, geographers at the French Research Institute for Development (Institut de Recherche pour le Développement – IRD) assesses accessibility without developing quantitative evaluation methods based, for example, on graph theory (see, e.g. Demoraes & d’Ercole, 2009). On the other hand, other researchers focus on these theories without applying a territorial concept of risk using accessibility as a means of comparing vulnerable areas with areas containing resources or providing shelter (see, e.g. Chang, 2003).

Territorial accessibility in crisis management depends on several concepts from the geography of environmental risk and of transportation (Leone et al., 2013a). In crisis management, the issue of territorial accessibility can be analysed according to the different phases of a crisis: pre-crisis (evacuation) or post-crisis (access to emergency needs and other resources) (Péroche, Leone & Gutton, 2014).

Territorial accessibility is also important for tsunami crisis management and it has been the subject of many tsunami related studies, particularly those on evacuation simulations. The types of territorial accessibility related to tsunami crisis management are summarized in Figure 7. According to this figure, several types of territorial accessibility may be defined and analysed as a function of vulnerable elements, including exposed populations, vital resources, and emergency facilities, or as a function of the typical phases of a tsunami crisis. These accessibility types are the following: (1) between at-risk zones and safe zones in the planning phase; (2) between resource zones and at-risk zones (or impacted zones) in the rescue phase; and (3) between safe zones and resource zones in the recovery phase. Accessibility and mobility within each of these zones must also be considered (based on Leone et al., 2013).

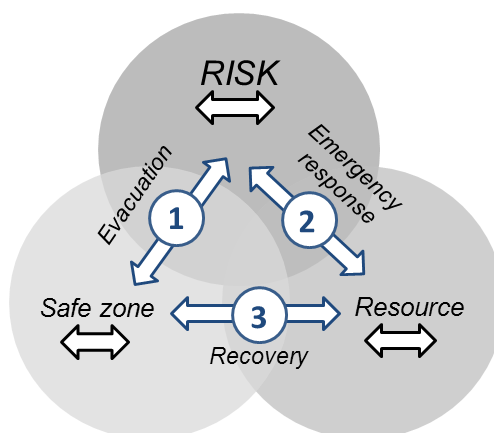


Fig. 7. Types of territorial accessibility related to tsunami crisis management (Adapted from Leone et al., 2013).

In case of planned evacuations for tsunamis, an accessibility model enables: (i) measuring the access time along the shortest routes between hazard zones and refuge areas; (ii) estimating the number of evacuees using accessibility curves according to the time, which allows us to estimate the number of people to be saved prior to the arrival of the tsunami; (iii) automatic selection of the evacuation sites and most relevant itineraries, based on the best pair time/distance route and the number of people who converge there (Leone et al., 2013b).

In the literature, there are a few studies focusing on accessibility related to tsunami crisis management. In their study defining loss of accessibility as the partial or total obstruction of access to the territory's vulnerable elements (including people, goods, economic activity, and various services), Leone et al. (2013) explores reproducible methodological protocols for modelling, mapping, and quantifying different types of accessibility (summarized in Figure 7) on the case of tsunamis and subsequent flooding on the coasts of Mayotte's two main islands where the tsunami risk is quite high. The modelling approach adopted in this study (in GIS environments, using graph theory and tools for calculating shortest routes) is based primarily on: graphs of roads (differentiating types of roads and defining average speeds), identification of vulnerable road segments, evaluation of vital elements (exposed populations and disaster management resources), identification of zones at risk of flooding, identification of safe zones, and estimated tsunami arrival times.

Péroche, Leone & Gutton (2014) introduces an accessibility graph-based model for optimizing tsunami evacuation sites and routes in two pilot municipalities of Martinique (Trinité and Sainte-Anne), France. The model is based on a population database at a local scale, the development of connected graphs of roads, the identification of potential safe areas and the velocity setting for pedestrians. The advantage of the proposed method is its reproducibility and adaptability to different scales of study (if the databases are available). Using the results of the model validated through a participatory field survey in collaboration with the public sector services and local authorities, evacuation reference maps are produced for both pilot municipalities.

Evacuation

Evacuation of potentially affected population in time towards safer grounds (e.g. higher grounds, vertical evacuation) to avoid the potential damage to people caused by the waves and/or by floating debris is a fundamental requisite for reducing vulnerability to tsunami risk to a satisfactory extent. The process of planning for evacuation is especially important in highly populated coastal regions and needs to be carried out in a detailed manner to achieve more efficient evacuation (Scheer, Varela & Eftyschidis, 2012). Consequently, tsunami evacuation planning is one key feature of tsunami risk management.

A tsunami evacuation plan has first to be set up. The aims and characteristics of a tsunami evacuation plan are described in Scheer, Varela & Eftyschidis (2012). It is important that the plan is implemented through regular monitoring, according to which the updates required can be identified. Hence, tsunami evacuation planning is strongly linked to studies on tsunami hazard assessment, early warning, and evacuation modelling. First and foremost, building tsunami evacuation plans requires the analysis of the territory in terms of tsunami hazard for assessing the exposure to the hazard, and quantifying the exposed population. Next, possible evacuation routes and shelter areas needs to be identified through evacuation modelling studies. The selection of appropriate routes and shelters should be based on accessibility criteria and should also consider the

needs of communities located in areas with limited opportunities for evacuation (Shal, Leone & Péroche, 2013; González-Riancho et al., 2013). A handbook for tsunami evacuation planning is provided by Scheer et al. (2011a) within the framework of the EU FP6 SCHEMA project (SCenarios for Hazard-induced Emergencies MAnagement). The handbook presents thorough and hands-on information accompanied by a fully- comprehensive methodology of tsunami evacuation plan generation. In this methodology, the local tsunami risk assessment and all subsequent implications for evacuation planning relies on the expected tsunami wave height, and the arrival time of the first devastating tsunami wave. A cost surface layer, evacuation shelter points, a time map, the area covered by each shelter point, the time distance from the closest shelter, the area served by exit/escape points, and the time distance to reach the closest escape point are among the aspects considered within the methodology. In the following paragraphs, the reviewed literature on modelling efforts related to tsunami evacuation is summarized based on González-Riancho et al. (2013). (Note: See also Péroche, Leone & Gutton for a brief overview of tsunami evacuation modelling).

In parallel with the advances in the understanding and prediction of tsunami impacts, there have also been considerable efforts in evacuation simulations. There are several works available in the literature that deal with different aspects of the evacuation process for a tsunami hazard. While some studies addresses the aspects related to tsunami hazard (e.g. calculation of the tsunami wave height, the flooded area, run-up, or arrival time), others concentrate on tsunami-related human aspects, such as the calculation of loss of lives, potential casualties, mortality vs. safety, human damage prediction, etc. There are also studies that analyse road characteristics as input information for evacuation modelling, as well as studies predicting the impacts on buildings using damage functions. The evacuation itself has been studied by several authors. The issues covered in these studies range from the identification of critical areas, the calculation of the evacuation time, to the assessment of warning procedures, among others. Developing specific evacuation modelling software has been the concern of most of the studies. Yet, very few authors focus on planning aspects of tsunami evacuation. Some examples from the previous works are as follows:

“Regarding the human damage prediction caused by flooding-related disasters, including tsunamis, Sugimoto, Murakami, Kozuki, Nishikawa & Shimada (2003) presented a tsunami human damage prediction method employing numerical calculation and GIS for a town in a high-risk area. The number of deaths as a result of a tsunami was estimated from the accumulated death toll, taking into account the time necessary to begin to seek refuge after an earthquake, tsunami inundation depth on land, flow velocity, and evacuation speed. Jonkman, Kok & Vrijling (2008) and Jonkman, Vrijling & Vrouwenvelder (2008) proposed a method for the estimation of loss of life due to flooding of low-lying areas protected by flood defences, which is given based on the flood characteristics, the exposed population and evacuation, and the mortality amongst the exposed population, using new mortality functions developed by analysing empirical information from historical floods. Koshimura, Katata, Mofjeld & Kawata (2006) estimated the number of casualties that may occur while people evacuate from a tsunami inundation zone, based on a simple model of hydrodynamic forces as they affect the human body. The method uses a tsunami casualty index computed at each grid point of a numerical tsunami model to determine locations and times where tsunami evacuation is not possible, and therefore where casualties are most likely to occur. This, combined with population density information, allows for the calculation of the potential number of casualties, which is useful information to identify locations which ought to be excluded from evacuation routes. Sato,

Murakimi, Kozuki & Yamamoto (2003) proposed a simplified method for tsunami risk assessment without wave run-up analysis, to qualitatively estimate the safety of residents, and examine the effectiveness of tsunami prevention facilities. Two normalized values are evaluated: the ratio of calculated maximum tsunami height to seawall height, and the ratio of the time between tsunami over-topping and evacuation completion to the total time required for evacuation.”

“Concerning the analysis of specific evacuation issues, Strunz et al. (2011), within the framework of the tsunami risk assessment for the German Indonesian Tsunami Early Warning System (GITEWS), analysed the evacuation of several Indonesian islands, considering vulnerability as the probability of not reaching safe areas in time. Alvear Brito & Cruz D’Howitt (2009) calculated the population evacuation time through a GIS-based numerical model, in which the critical zones (where the population will not have sufficient time to reach the security areas) are identified by considering factors such as the distance to security zones, the land slope, and accessibility of roads. Clerveaux & Katada (2008) presented a tsunami scenario simulator, which combines the hydrodynamic simulation of tsunamis with warning and human response simulations for evacuation, mainly focusing on alert communication aspects.”

In urban areas, large-scale evacuations are necessary. Agent-based modelling approaches have been widely used for this purpose in simulating evacuations, including tsunami evacuations as well. The advantage of this approach is its ability to model agents’ interaction and behaviour (Mas, Adriano & Koshimura, 2013). Considering the fact that human behaviour aspects is of great effect on the evacuation, agent-based modelling is likely to become more widely used in evacuation modelling studies. Some recent example studies on tsunamis are Lämmel (2011); Mas, Imamura & Koshimura (2012); Sahal, Leone & Péroche (2013). A brief review of the most recent tsunami evacuation models is provided in Mas, Adriano & Koshimura (2013).

As for the studies on tsunami evacuation relating the planning aspects, Scheer, Varela & Eftyschidis (2012) proposes a generic framework for tsunami evacuation planning which addresses the needs of decision makers. Tested along some Mediterranean communities, the methodology allows implementation of the plan in case of unavailability of simulation tools for estimating the relevant tsunami parameters (expected wave height and expected arrival time of the tsunami) through a more qualitative approach, i.e. using some rules of thumb or just normal logical thinking. Johnstone & Lence (2012) demonstrates how flood, loss, and evacuation models can be employed for assessing exposure (i.e. potential losses) and improving emergency response plans in communities prone to tsunamis. The presented results for the Vancouver Island in British Columbia point out the significance of self-activation and rapid protective action. Scheer, Guillande & Gardi (2011b) proposes optimizing tsunami evacuation plans through the use of building damage scenarios to identify potential vertical shelters. Taubenböck et al. (2009) notes the importance of interdisciplinary integration of social, remote sensing, and engineering sciences in contributing to a tsunami early warning and evacuation information system. Combining inundation modelling and urban morphology analysis with population assessment and socio-economic analysis of the population for evacuation modelling, they suggest mitigation strategies in relation to spatial planning and coping capacity for the coastal city of Padang, Indonesia. The study further analyses the factors influence different responses/behaviour to the tsunami early warning and coping capacity of various social groups in emergency situation.

Recognition of the differences in vulnerability arising from spatial and temporal factors is indeed important for evacuation planning and management. Freire, Aubrecht & Wegscheider (2013) presents an advanced geospatial approach for evacuation simulation which takes into account the time dependence of population exposure to tsunami threat. Combining different sources of information, namely, infrastructure, land use, and terrain slope, into the tsunami hazard map, evacuation speed of the people in the city of Lisbon is assessed. The approach proposed enables creating different evacuation maps for daytime and night time through detailed evaluation of dynamic population exposure.

“Works on evacuation modelling software may be grouped into three categories, according to the FLOODsite project (HR Wallingford, 2006): (i) traffic simulation models, (ii) evacuation behaviour models, and (iii) timeline/critical path management diagrams. Kolen, Kok, Helsloot & Maaskant (2010) described the EvacuAid probabilistic evacuation model, which determines the expected value and bandwidth for the success and loss of life of evacuation strategies based on four parameters: the available time, the behaviour of people, the behaviour of authorities and the available infrastructure and resources. van Zuilekom, van Maarseveen & van der Doef (2005) developed the Evacuation Calculator to compute how much time is required for evacuation, and to determine the effect of traffic management during the evacuation process on the required evacuation time. It focuses on traffic flows, and not on individual people or vehicles, and requires data about the average vehicle speed, the capacity of the exit point, the source zones and exits, the distance between them, and the number of people present in each source zone. BC Hydro (2004) developed the Life SafetyModel which allows dynamic interaction between the receptors (e.g. people, vehicles and buildings) and the flood hazard. It requires data about the location of individual properties, vehicles and people, the flood depths and velocities from a two-dimensional hydraulic model, and details of the road network and other pathways. Aboelata & Bowles (2005) proposed the LIFESim model for the estimation of potential loss of life from natural and man-made (dam and levee failure) floods, which comprises three modules: loss of shelter, warning and evacuation, and loss of life.”

“As mentioned above, different partial aspects of tsunami risk and evacuation are addressed in the literature. With a view to the successful planning of the evacuation of the population located in a tsunami prone area, several gaps in the prevailing science are identified: (i) no direct relationship between the specific evacuation-related assessments carried out and the formulation of risk reduction measures and/or an evacuation plan exists, even though some general connections are usually established; (ii) an assessment of the characteristics of the population and communities to be evacuated is not usually undertaken, (iii) the evacuation time is sometimes calculated without considering the tsunami arrival time, resulting in a lack of information regarding the degree of success that the identified evacuation time represents for the population; (iv) an analysis of the time needed by the responsible administrations to issue the tsunami warning and to inform the population is sometimes not considered, although this is essential information for determining the real time available for the population to evacuate; (v) the evacuation modelling results sometimes do not identify, propose or suggest conclusions about how to reduce the risk of the populations identified in critical areas, regarding successful evacuation; and (vi) proposals for improvements in the evacuation process are frequently inadequate, lacking identification of locations to build new vertical shelters and evacuation routes, and omitting warning time reduction strategies, etc.”

A comprehensive tsunami evacuation planning framework eliminating above identified gaps is given by González-Riancho et al. (2013). As can be seen in Figure 8, the proposed methodological

approach has three main phases: analysis, modelling, and planning. It considers (i) the hazard aspects (tsunami flooding characteristics and arrival time), (ii) the characteristics of the exposed area (people, shelters and road network), (iii) the current tsunami warning procedures and timing, (iv) the evacuation time needed by the population, and (v) the identification of measures to improve the evacuation. It thus aims to bridge the gap between risk assessment and management in tsunami evacuation. The framework has been applied to the El Salvador case study, demonstrating its applicability to site specific response times and population characteristics.

Planning the proper evacuation of areas under tsunami risk based on various modelling studies is not adequate alone to achieve successful evacuation. Based on the established evacuation plans, providing citizens from a city/province/country with strategic information on evacuation maps and some general guidelines about what to do in case of emergency is highly important. Design of tsunami evacuation maps requires much attention as well (discussed in detail in Section 2.4) for that there are various factors affecting understandability of the maps by the people. Yet, the real challenge of sustaining effective and efficient evacuation lies behind dealing with evacuation as a community process and understanding behavioural responses to evacuation at the individual level. A brief review of the relevant literature is presented in the next couple of paragraphs.

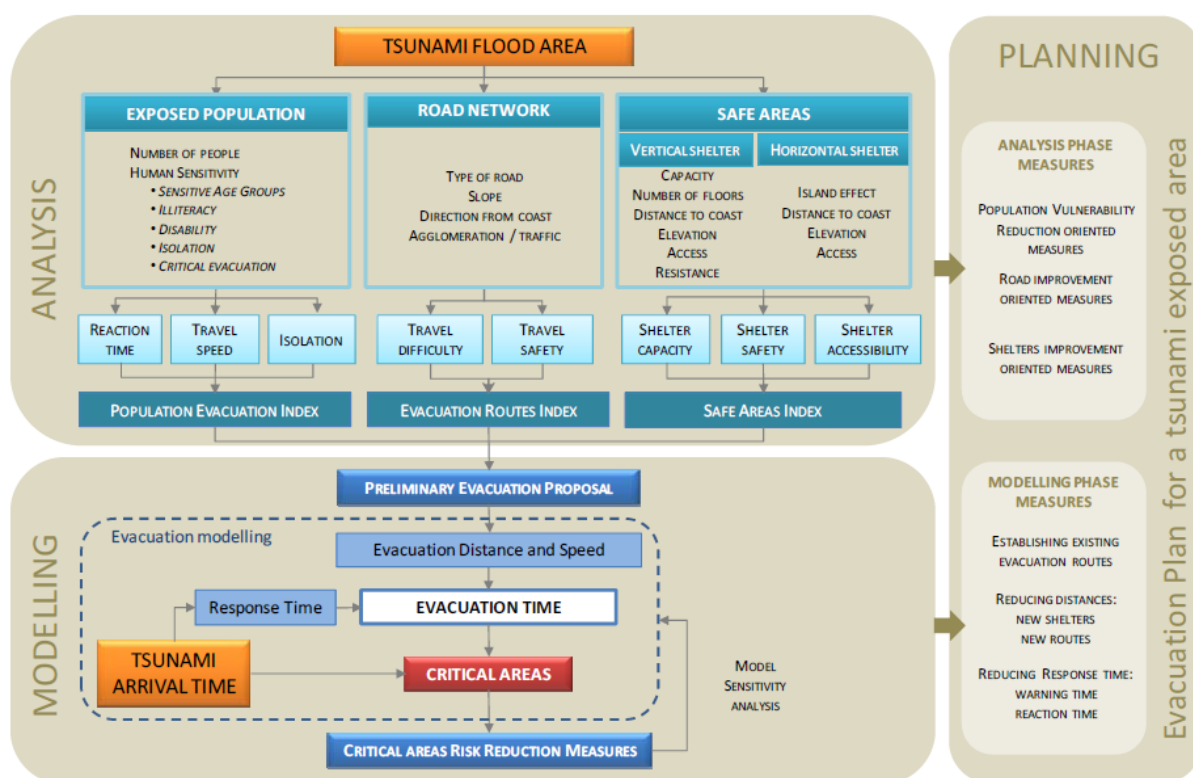


Fig. 8. Tsunami evacuation planning framework presented in González-Riancho et al. (2013).

In most of the natural disasters, the principal protective action is evacuation, and it is both a community and individual process. Sorensen & Sorensen (2007) discusses warning and evacuation as a community process, and briefly reviews the social construction of evacuation and the changing social and technological context of evacuation in the United States. The major empirical research findings on public behaviour in evacuations with respect to warning and warning response, adoption of warning systems, timing of warning receipt, and factors influencing household decision to evacuate are summarized. The societal characteristics of evacuation behaviour as well as

organizational response aspects of evacuation planning are also highlighted. A review of the literature on warning, risk perception, and evacuation within hurricane research is provided by Dash & Gladwin (2007). There are few relevant studies on tsunamis, which are shortly mentioned here.

Fraser, Leonard & Johnston (2013) investigated hazard awareness and intended evacuation behaviour in a hypothetical local earthquake and tsunami in Napier, New Zealand. Although there can be differences for evacuation behaviours observed in an actual event, analysis of the evacuation behaviours shows consistency with international literature on evacuation behaviour. It was found that demographic factors (gender and location at the time of the earthquake) are influential in respondents' intention to evacuate, and their travel mode intentions. Mas, Imamura & Koshimura (2011) develops a tsunami evacuation model based on risk perception, experience, warning information, social influence, and time pressure. The decision process involving human behaviour in emergency situation is modelled using the Risk Perception Level (RPL) at three stages (pre-decision, decision-making, action), and accordingly a risk perception framework is built for tsunami evacuation decision. Goseborg et al. (2014) identifies the potential evacuation routes for the city of Padang, Indonesia based on assessment of social vulnerability related with people's exposure to tsunami hazard, their risk perception, and evacuation behaviour – in addition to the assessment of physical vulnerability. Charnkol & Tanaboriboon (2006) analyses evacuation behaviour of residents of Phuket and Phang-ga, Thailand during a hypothetical tsunami evacuation under different preparation and response time intervals. A tsunami evacuation model is then developed employing binary logistic regression technique in estimating the evacuation response and factors affecting tsunami evacuation. It was found that while disaster knowledge and number of children in families was positively correlated with quick response patterns of evacuation, number of family members had a negative correlation.

Identification of most appropriate evacuation style is another aspect which needs to be decided upon. In their study Fraser, Leonard & Johnston (2013) found that vertical evacuation is recognized by the respondents as a potentially life-saving option if it is not possible to reach high ground in a hypothetical local earthquake and tsunami in Napier, New Zealand. Johnstone & Lence (2012) assess whether evacuation on foot, in vehicles, or in combination is most effective for the District of Ucluelet in British Columbia.

The lessons learned from past tsunamis can have significant benefits regarding many aforementioned aspects related to evacuation planning, procedures, and operation. There are a number of reports and/or articles serving for the purpose of transferring and sharing such knowledge and experience. For example, the knowledge notes from the Learning from Megadisasters Project (IBRD/World Bank, 2012) examine the experiences from the Great East Japan Earthquake of 2011 on evacuation planning and evacuation centre management (among many other areas of recommendations). Similarly, Suppasri et al. (2013) evaluates the evacuation during the 2011 East Japan earthquake and tsunami but with respect to performance of evacuation buildings and shelters. Imamura (2009) on the other hand focuses on dissemination of information (received warnings) and evacuation procedures in the 2004-2007 tsunamis in the Indian and Pacific Oceans.

2.4. Review on existing tools dedicated to tsunami awareness and preparedness

The awareness on the importance of tsunami hazard in coastal areas has increased following the recent tsunami events in the Pacific and Indian Ocean (IOC/UNESCO, 2013). Consequently, raising tsunami awareness and preparedness have been at the forefront of attempts to increase resilience towards tsunamis at coastal communities in at-risk areas. In this direction, local authorities, regional governments and NGOs as well as international organizations (and UN agencies) play a vital role for management of tsunamis.

In her study of tsunami science research, Keating (2006) invited researchers to increase their efforts on the topics of education and tsunami risk, which are topics with the least number of publications. Following this call, there have been various efforts by many international organizations, agencies, local authorities, and NGOs to decrease the deficiency in educational material available in the literature everywhere in the world.

This part of the report is aimed at exemplifying such publications (report, manuals and guides) in attempt to these efforts and providing a review on a variety of existing tools (brochures, posters, signs, etc.) dedicated to tsunami awareness and preparedness. First, the prominent organizations serving at the global level for the purpose of raising awareness and preparedness are introduced. Then the existing tools are exemplified.

International organizations and agencies

UNESCO's Intergovernmental Oceanographic Commission (IOC/UNESCO) and the International Tsunami Information Centre (ITIC) are the major leading organizations worldwide. Within IOC/UNESCO, there is a special programme for tsunamis: the IOC Tsunami Programme. Acting as a key stakeholder at global level, the programme is aimed at reducing the loss of lives and livelihoods that could be produced worldwide by tsunamis through supporting IOC Member States on various tasks (e.g. assessment of tsunami risk, implementation of Tsunami Early Warning Systems, education of communities at risk about preparedness measures). IOC/UNESCO is responsible for addressing the needs and the management of regional Intergovernmental Coordination Groups (ICGs) developed for tsunami warning systems in the Pacific Ocean, in the Indian Ocean, in the Caribbean Sea, and in the North-East Atlantic, Mediterranean and connected seas region – which are:

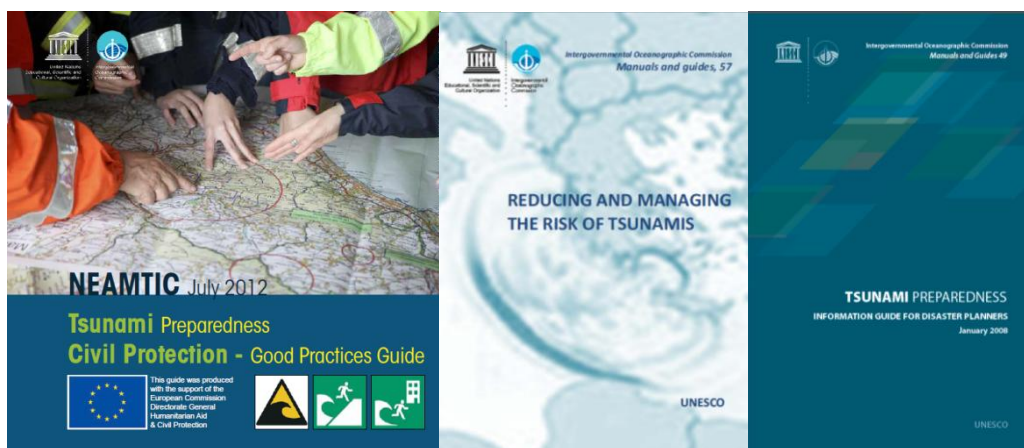
- The Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE EWS)
- The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS)
- The Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG/NEAMTWS)
- The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS)

As part of ICG/NEAMTWS, a Tsunami Information Centre for the NEAM region – called NEAMTIC – was also established with the aim of increasing awareness and preparedness of the general public, which is an essential requirement for such tsunami warning systems to be successful and effective. NEAMTIC provides information on warning systems, risks and good practices in respect of tsunamis and other sea-level related hazards for civil protection agencies, disaster management, decision makers, schools, industries in the coastal zone and the general public.

Manuals, guides, and reports for the authorities

IOC/UNESCO produces many publications in the form of manuals, guides or brochures. Considering their purposes and their target audience, the following publications of IOC/UNESCO are worth mentioning (Figure 9):

- *Preparedness - Information Guide for Disaster Planners. IOC Manual and Guides No. 49 by Intergovernmental Oceanographic Commission of UNESCO (2008):*
 In this guide document, prepared in the light of the “Guidebook for Tsunami Preparedness in Local Hazard Mitigation Planning” by the Government of Japan in 1998, the basic requirements of tsunami hazard mitigation planning, and tsunami preparedness are explained.
- *Tsunami Preparedness Civil Protection - Good Practices Guide. IOC Manuals and Guides No. 65 by Intergovernmental Oceanographic Commission of UNESCO, North-Eastern Atlantic and the Mediterranean Tsunami Information Centre (2013):*
 The report “Tsunami Preparedness Civil Protection - Good Practices Guide” by the NEAMTIC (IOC/UNESCO, 2013) summarizes a group of guidelines which can help civil protection authorities and coastal communities understand their exposure to tsunami hazards and to mitigate the resulting risk through awareness, preparedness information and land use planning. Strategic approaches are also proposed for a more effective development of tsunami risk awareness campaigns. In the light of discussion on different individual, community awareness and preparedness policies, this report proposes strategic approaches and guidelines for a more effective development of tsunami risk awareness campaigns. Presenting the best practices, it is aimed to support civil protection authorities for providing public education and outreach.



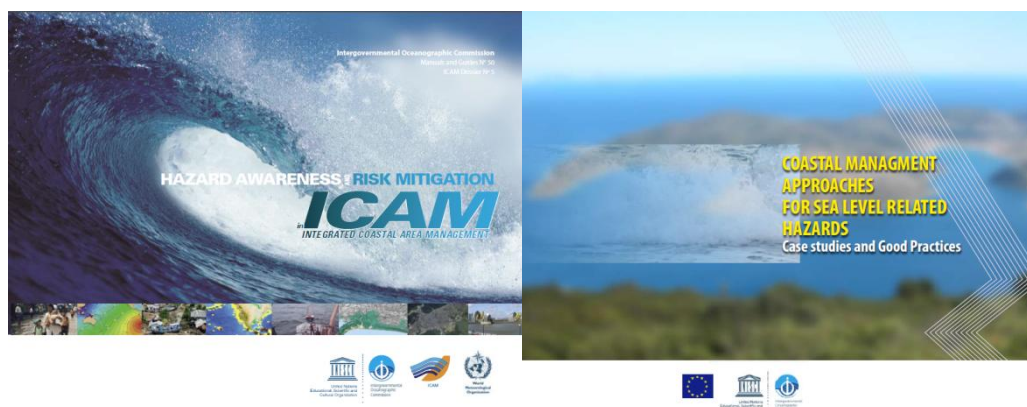


Fig. 9. Examples from the IOC/UNESCO publications for raising tsunami awareness and preparedness.

- *Coastal Management Approaches for Sea-level Related Hazards: Case Studies and Good Practices. IOC Manuals and Guides No. 61 by Intergovernmental Oceanographic Commission of UNESCO (2012):*
By elaborating on examples of good/bad practices in promoting tsunami awareness and preparedness (as well as for other sea-level related hazards) particularly in the NEAM region, this report provides useful insights and lessons for coastal risk and climate change managers and policymakers, development planners, and practitioners at both national and local levels.
- *Hazard Awareness and Risk Mitigation in Integrated Coastal Management (ICAM). IOC Manual and Guides No. 50 by Intergovernmental Oceanographic Commission of UNESCO (2009):*
National and local government agencies working for the sake of management of coastal areas can make great use of these guidelines which are aimed at facilitating the reduction of the tsunami, storm surges, and other coastal hazard risks to coastal communities, their infrastructure and associated ecosystems.
- *Reducing and managing the risk of tsunamis. IOC Manuals and Guides No. 57 by Intergovernmental Oceanographic Commission of UNESCO (2011):*
The target of this report is national Civil Protection agencies and Disaster Management Offices of countries within the NEAM region. In respect of tsunami hazard within a multi-hazard context, it is capable of supporting and supplementing existing procedures for tsunami risk assessment and mitigation in these countries.

Guides, brochures, and posters as means to educate the public

Despite the fact that education is not a focal point of tsunami research, scientific papers often underline the need for preventive educative activities among coastal populations. This tendency has increased since the 2004 Indian Ocean tsunami which unfortunately highlighted many examples of inappropriate public reactions facing an impending tsunami.

Educational documents such as small guides, brochures and posters can be of great help for increasing the level of awareness and preparedness of the public. An example guide document on tsunamis for the general public is produced by the Department of Disaster Management of the Virgin Islands (UK). The document is called “A Guide to Tsunamis for Families & Businesses” (published in 2009) and introduces the tsunami hazard alongside with a history of tsunamis in the

Virgin Islands. It also touches upon various basic concepts such as tsunami warning signs and emergency alert system. The document also guides people on how to create an evacuation plan for different types of tsunami (i.e. locally generated vs. regional/distant generated) as well as recovery process. The cover page and the table of contents can be seen in Figure 10.

The Intergovernmental Oceanographic Commission (IOC/UNESCO) has recently published the newest version of “The Tsunami Glossary” (Figure 11). While the 2008 version of it is available in English, Spanish, French, and Indonesian, the 2013 version is available in only English and Arabic. The glossary provides the definition of a variety of technical terms, and gives information on the IOC Global Tsunami Warning and Mitigation Systems (e.g. ICGs). This glossary is rather comprehensive but potentially less understandable to the general public. There is also a 12-page glossy brochure (“Tsunami – The Great Waves”, by ITIC and IOC/UNESCO – Figure 12) which has a simpler language thus more understandable by all people. It explains “*what a tsunami is, how fast and how big they can be, what causes them, and describes programs undertaken to mitigate this hazard, including the development of tsunami warning centres, research programmes, and safety rules describing what to do when a tsunami attack your coastline*”. The December, 2012 version is available in Spanish, French, and Chinese.



Fig. 10. The tsunami guide for the Virgin Islands (UK) (Available at: <http://www.bviddm.com/document-center/Tsunami%20Guide%20-%20Copy.pdf>)

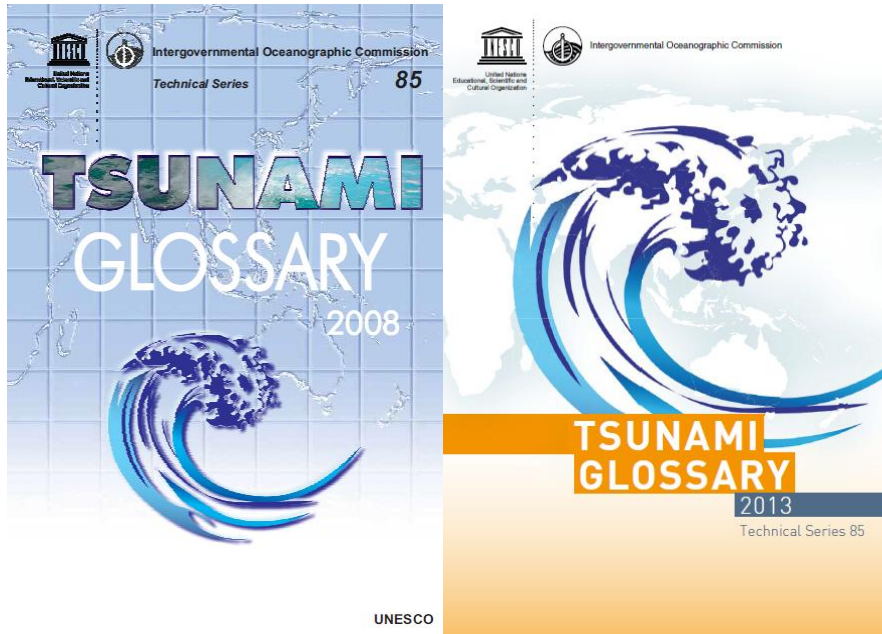


Fig. 11. The Tsunami Glossary by IOC/UNESCO

(On the left: 2008 English-version, on the right: 2013 English-version) (Available at: http://itic.ioc-unesco.org/images/stories/about_tsunamis/tsunami_glossary/tsunami_glossary_en_2013_web.pdf)

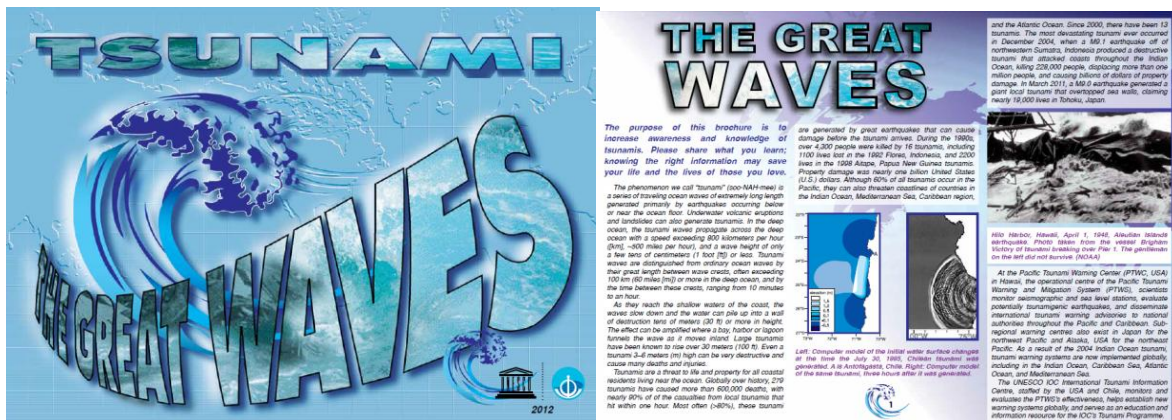


Fig. 12. Tsunami, The Great Waves

One of the main tasks of ITIC is to develop educational materials for raising tsunami awareness and preparedness which can be also used as a template or customized for different languages. For example, the “Tsunami Awareness Poster” shown in Figure 13 is intended to give simple and brief information on tsunami. Emphasizing the importance of knowledge, the poster explains tsunami warning signs and proposes the things that should be done in case a tsunami occurs. The poster is available in Spanish, Chinese, Korean, Japanese, French and Portuguese. More examples of materials for raising awareness and preparedness can be found in “Awareness & Education” section of the ITIC website <http://itic.ioc-unesco.org/>.

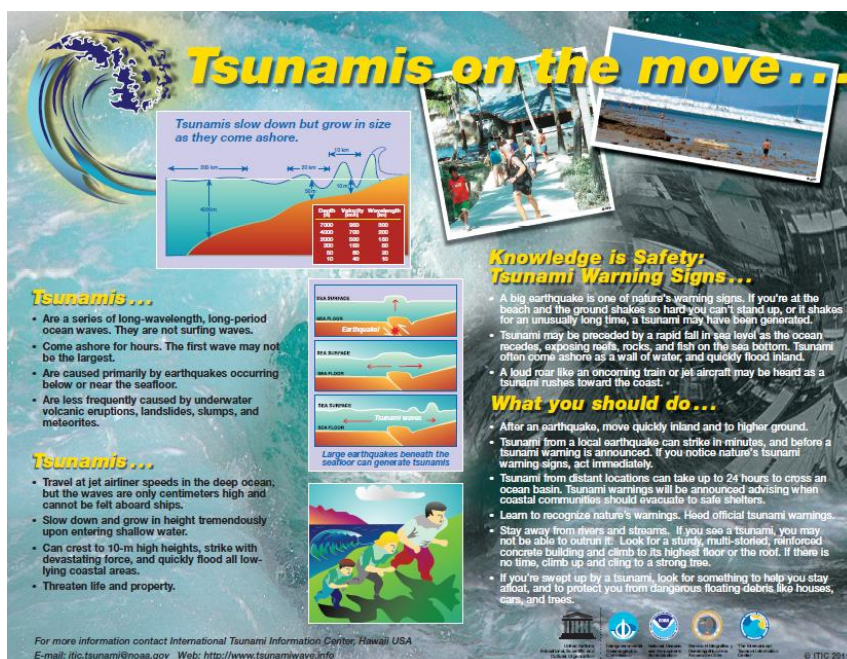


Fig. 13. Tsunami Awareness Poster (English) by the International Tsunami Information Centre (Available at: http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1327&Itemid=2406&lang=en)

With the support of the European Commission, NEAMTIC has also developed a variety of educational materials and activities to improve the preparedness of citizens, especially youth, and civil protection authorities. Guidelines, posters, online courses, games and videos are among the tools developed which are available through the NEAMTIC website (<http://neamtic.ioc-unesco.org/>). The flyer explaining tsunami hazard and risk in the NEAM region is presented in Figure 14.

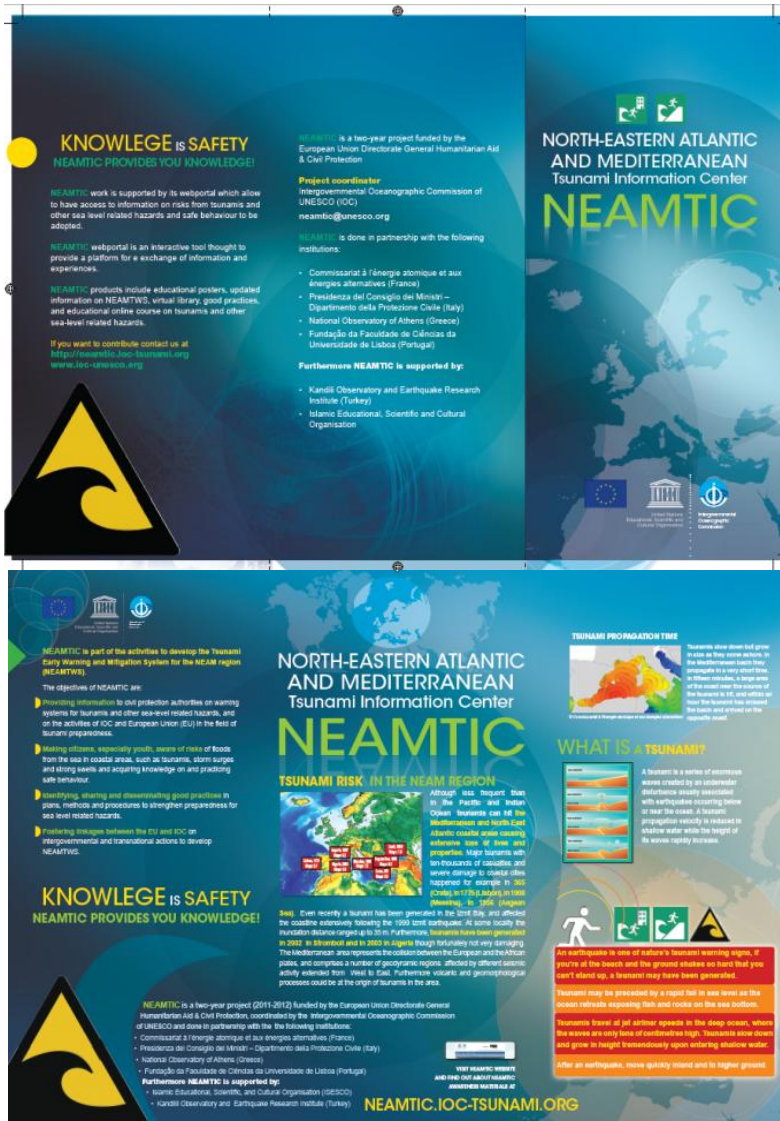


Fig. 14. A flyer on tsunami hazard and risk by the NEAMTIC and IOC/UNESCO.

Considering the fact that the coasts of NEAM region are among popular tourist destinations, it is also important to prepare materials targeted at tourists. Figure 15 shows a poster (in English) designed specifically for tourists – “A guide to tsunamis for hotel guests” by NEAMTIC and IOC/UNESCO. In this poster, tsunami risk in the NEAM region is explained and evacuation procedures are described.

Availability of materials introducing children the concept of tsunami and making them familiar with this natural hazard is another important aspect of raising awareness. In this respect, NEAMTIC has prepared a poster (Figure 16) in which tsunami facts and public safety considerations are explained with the help of painting games and cartoon characters (Superneamtic, Tsumino, and Seadrop).

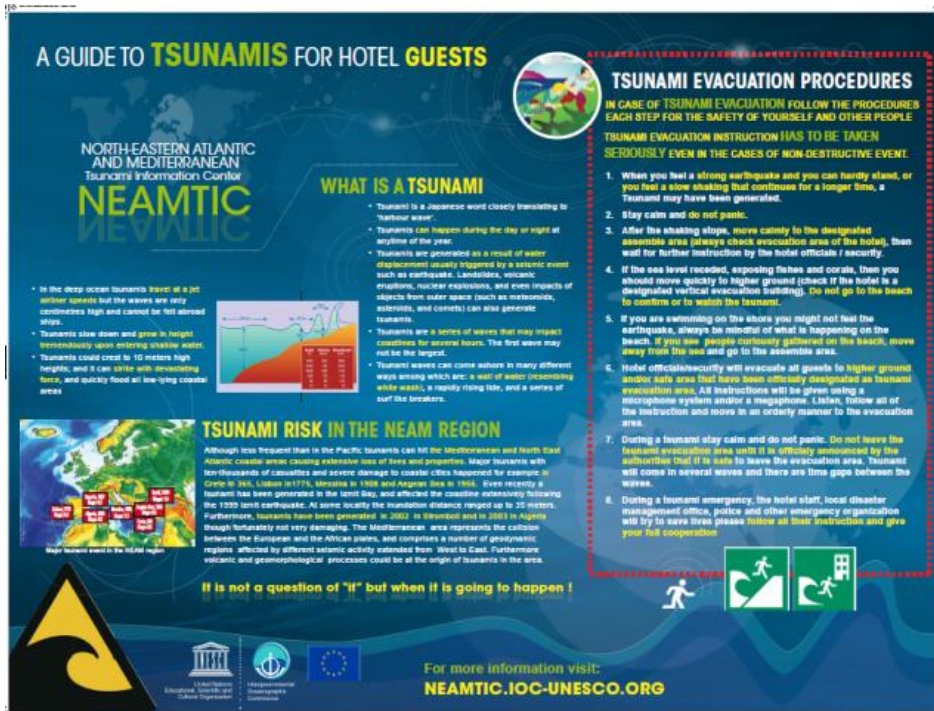


Fig. 15. The poster guide for hotel guests by the NEAMTIC and IOC/UNESCO.



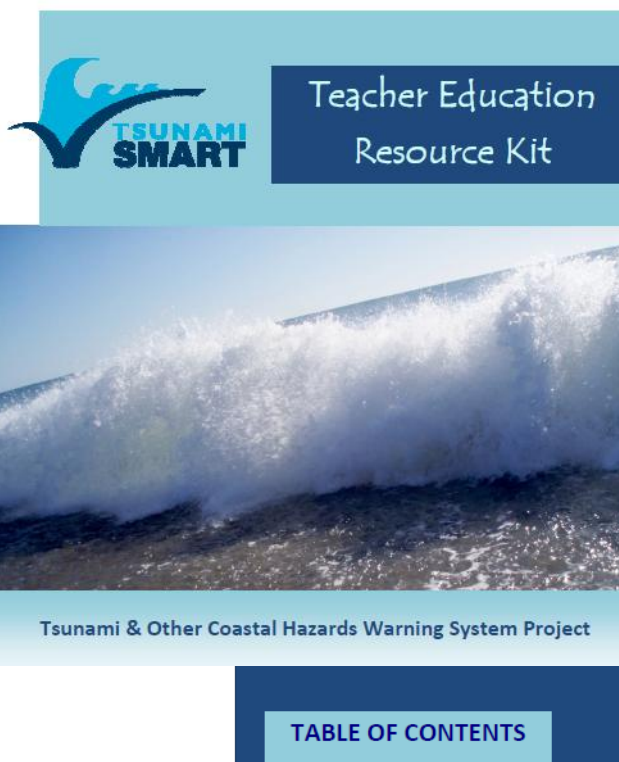
Fig. 16. The educational materials for children by the NEAMTIC

In the Caribbean, in an effort to increase resilience against tsunamis, the Tsunami and Other Coastal Hazards Warning System Project (2010) has been implemented by the Caribbean Disaster Emergency Management Agency (CDEMA) in partnership with United States Agency International Development (USAID), The University of the West Indies Seismic Research Centre, and TSUNAMISMART. The project involved production and dissemination of materials for public awareness and education. Tsunami brochures developed under three main tsunami themes (science, impact, and safety) are one example and can be seen in Figure 17. The same project has also come up with a teacher education resource kit (Figure 18) designed to support the teaching of tsunami science and safety in the classroom. It includes four lessons on tsunamis: (1) Be tsunami smart!, (2) Experiencing a tsunami, (3) Teach your elders about tsunamis, (4) Preparing for a tsunami. Each

lesson has a teacher’s guide and student workbook, and covers a range of inquiry-based activities such as slideshow presentations. There is also a tsunami glossary and Frequently Asked Questions (FAQ) section inside the document.



Fig. 17. Tsunami brochures in the Caribbean



NOTES TO TEACHERS	5
RATIONALE FOR A TEACHER RESOURCE KIT	5
HOW TO USE THIS BOOK	6
USEFUL WEBSITES	7
TEACHER'S GUIDE	8
LESSON 1 – BE TSUNAMI SMART!	8
LESSON 1 CONTENT – BE TSUNAMI SMART	9
LESSON 2 – EXPERIENCING A TSUNAMI	10
LESSON 2 CONTENT – EXPERIENCING A TSUNAMI	11
LESSON 3 – TEACH YOUR ELDERS ABOUT TSUNAMIS	14
LESSON 3 CONTENT – TEACH YOUR ELDERS ABOUT TSUNAMIS	16
LESSON 4 – PREPARING FOR A TSUNAMI	24
LESSON 4 CONTENT – PREPARING FOR A TSUNAMI	25
FREQUENTLY ASKED QUESTIONS	29
TSUNAMI GLOSSARY	32
GRAPHIC ORGANIZERS	35
APPENDIX	41
THE CHRISTMAS ANGEL	41
COLOURS	47
MAKING HEROES OUT OF CHILDREN WITH A NEW EMERGENCY PREPAREDNESS PROGRAMME	50
CARIBBEAN TSUNAMIS	51
"STOP DISASTERS" – AN ONLINE GAME	54
REFERENCES FOR TSUNAMI SMART TEACHING CHARTS	55
TEACHERS INVOLVED IN REVIEW OF TSUNAMI SMART TEACHER EDUCATION RESOURCE KIT	57

Fig. 18. The education resource kit for teachers – an example from the Caribbean

Videos

Videos are effective tools of increasing awareness and preparedness as well. The video “Tsunami Teacher USA” created by ITIC explains the basics of tsunamis and the ways of protection against tsunamis. In this 6:36 minutes video (available in English and Samoan), the Samoa Tsunami in 2009 is used as a case study to depict various topics. Another example video is provided by the Emergency Management British Columbia: “Tsunami 101”. Aimed at engaging British Columbians on preparedness and response activities, the video introduces the basic elements of tsunami (e.g. generation mechanism, factors influencing the magnitude of tsunami waves) and provides the tsunami history from the British Columbia perspective using the 2012 Haida Gwaii tsunami as an example. The animated short film produced by the San Diego County to educate kids about tsunamis is another good example. The cover pages of the videos can be seen in Figure 19.

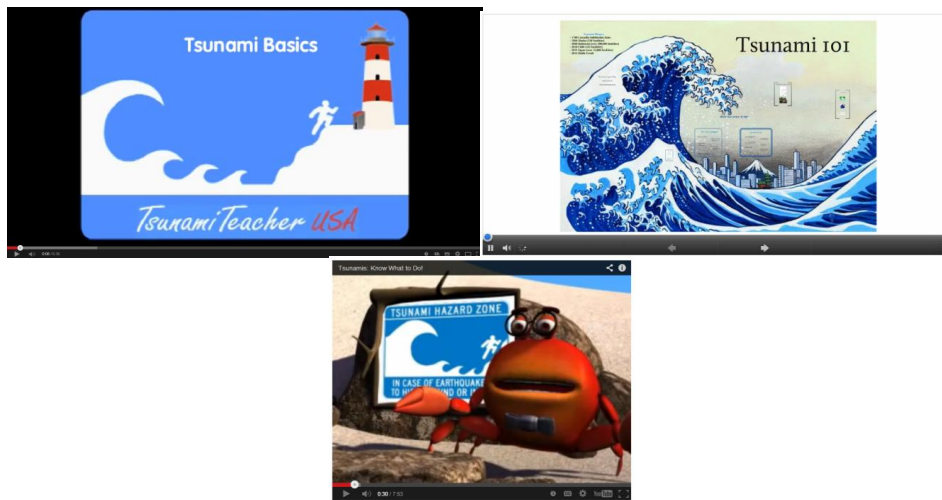


Fig. 19. Videos on tsunami as educational materials by ITIC (on the upper left), Emergency Management British Columbia (on the upper right), and San Diego County (Available at: http://www.youtube.com/watch?v=tUN_UTY0GNo&list=PL3BDBAAAA7D4EB2DA&index=11, http://prezi.com/6uh4yak0ke_g/tsunami-101/?utm_campaign=share&utm_medium=copy, and <https://www.youtube.com/watch?v=UzR0Rt3i4kc#t=30> respectively)

After the 2004 Indian Ocean Tsunami, a 30 min Franco-Indonesian documentary film was produced by the French NGO Planet Risk and the CNRS Image with the advice of scientists (Morin et al., 2008). The film begins with a survival testimony, a method used at the Pacific Tsunami Museum for its power to catch the public attention (Dudley, 1999). Then it describes the tsunami history in Indonesia and past disasters, through screens of the 1907 (Simeulue), 1994 (West Java) and 2004 (Banda Aceh) tsunamis, in order to raise population awareness regarding the phenomenon frequency. It also presents in a pedagogic way: tsunami sources and mechanisms, forewarning signs, life guard’s advice, and an evacuation drill on Java southern coast, in order to teach the population the right attitude during a tsunami. The movie is supplemented with educational leaflets (Figure 20) and sets of six pedagogic posters which complement the content of the movie, and with a photographic exhibition of the 26 December 2004 tsunami. The educational aids were participatory developed, taking into account scientific findings and advice as well as the opinion of people from various origins (teachers and students, villagers, stakeholders in risk management and authorities, etc.) through informal arguments and committee stages as well as official interviews, to define their form and content. A first version was tested (by all these categories too) and was improved,

following the advice harvested, to make its content as clear as possible. TA definitive version was then disseminated in the South Java threatened coastal villages.

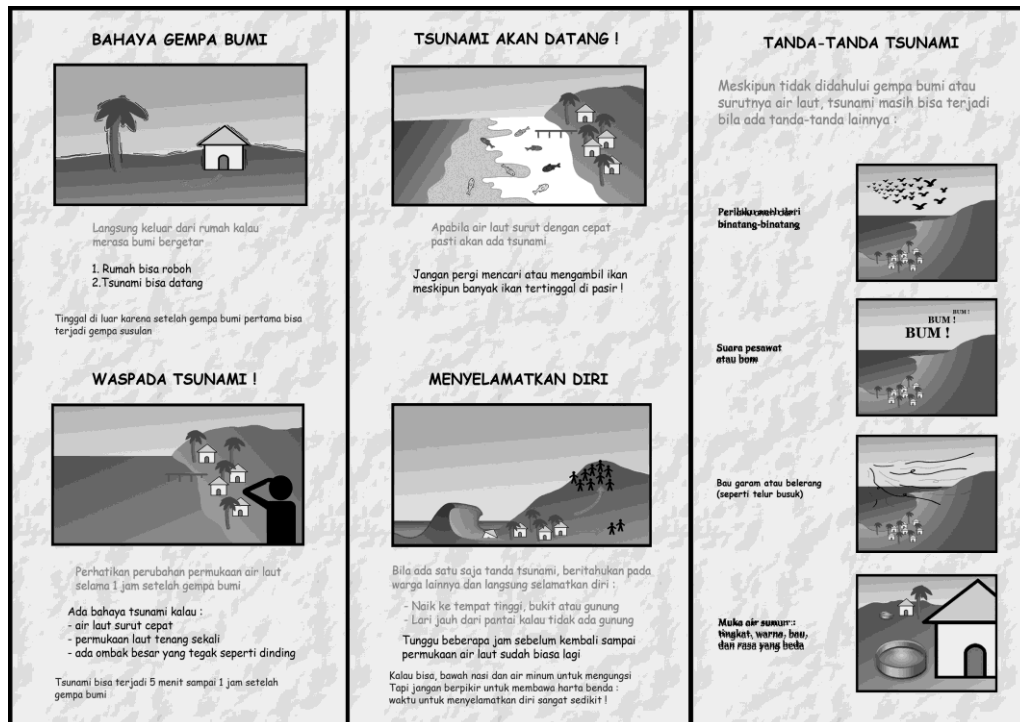


Fig. 20. The leaflet introducing forewarning signs of an impending tsunami distributed to Indonesian public.

Tsunami signage

Tsunami signage is of fundamental importance for the coastal communities. There is a variety of signage around the world, but all serve for the very same purpose. Some present examples of tsunami signage are provided in Figure 21.

An alternative signage for tsunami safe zone is proposed by the Wellington Emergency Office in New Zealand: “Blue Line application”. The Blue Line painted, as shown in Figure 22, marks the tsunami safe zone – an area identified to be out of any possible tsunami based on the modelling studies undertaken by the GNS Science. Different than the usual warning signs, this new warning sign aims to raise community awareness on tsunami evacuation, and is expected to reduce sign pollution as well. Blue Tsunami Lines project has won awards in two categories “Global, and Ocean Public Awareness” of the International Association for Emergency Managers in 2012. Although effectiveness of such application has not been quantitatively assessed yet, the Wellington City Council is planning to extend the project (<http://www.stuff.co.nz/>; <http://wellington.govt.nz/>).



General examples of tsunami signage approved by ISO
(from left to right: horizontal evacuation, vertical evacuation, evacuation zone, and)



Tsunami information board in Indonesia.

Tsunami hazard zone signage in the USA.



Tsunami hazard zone signage in Chile.

Tsunami hazard zone signage in the United States.



Tsunami safe areas from left to right: Japan, New Zealand, Alaska.

Fig. 21. Some examples of tsunami signage



Fig. 22. The Blue Line application in Wellington, New Zealand (<http://www.stuff.co.nz/>)

The role of local authorities' websites is undeniably great for promoting tsunami resilience by means of aforementioned activities for raising awareness and preparedness. In this regard, the Oregon

Tsunami Clearinghouse working under the State of Oregon Department of Geology and Mineral Industries is worthwhile mentioning. Their website (Figure 23) acts as a hub providing all the necessary tsunami-related information targeted at different audiences. It can be used as a guiding example for other authorities in designing their own website. Yet another example of website can be given, that of the Wellington City Council (<http://wellington.govt.nz/about-wellington/emergency-management/prepare-for-an-emergency/tsunami>). Although not as comprehensive as of the Oregon Tsunami Clearinghouse, it provides basic useful information to the public.

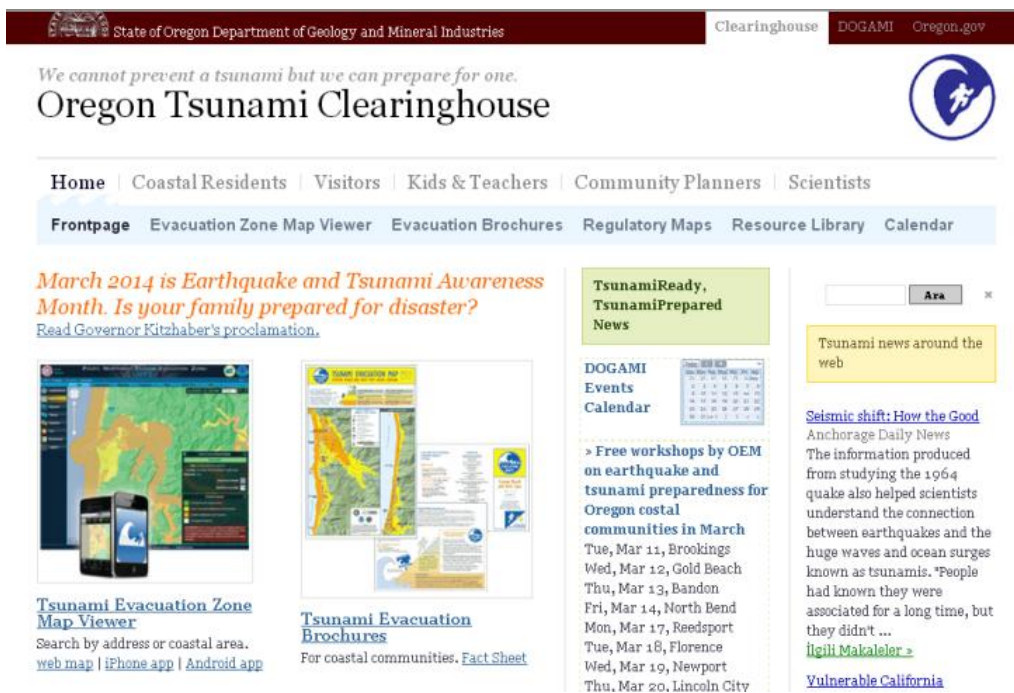


Fig. 23. The website of the Oregon Tsunami Clearinghouse (<http://www.oregongeology.org/tsuclearinghouse/>)

Tsunami evacuation maps are among the most needed tools for increasing preparedness of communities. The maps basically show three types of information: (i) evacuation zones, (ii) evacuation routes, and (ii) safe areas. It is expected that predictions for the maximum extent of inundation for local and distant tsunamis are seen on these maps. The website of the Oregon Tsunami Clearinghouse provides access to all the evacuation maps available in the region. The tsunami evacuation map for the Cannon Beach is shown in Figure 24. An issue that needs to be considered when tsunami evacuation maps are designed is the selection, generalization, and symbolization of information content (Kurowski, Hedley & Clague, 2011), on which both natural and social scientists should work together. These are all important factors affecting understandability of the evacuation maps by the local people. Public assessment of the potential usefulness of tsunami evacuation maps (see, e.g. Dall’Osso & Dominey-Howes, 2010) is thus a fundamental task which should be carried out by the responsible agencies/offices (mainly local government planners and emergency risk management specialists) for establishing evacuation plans.

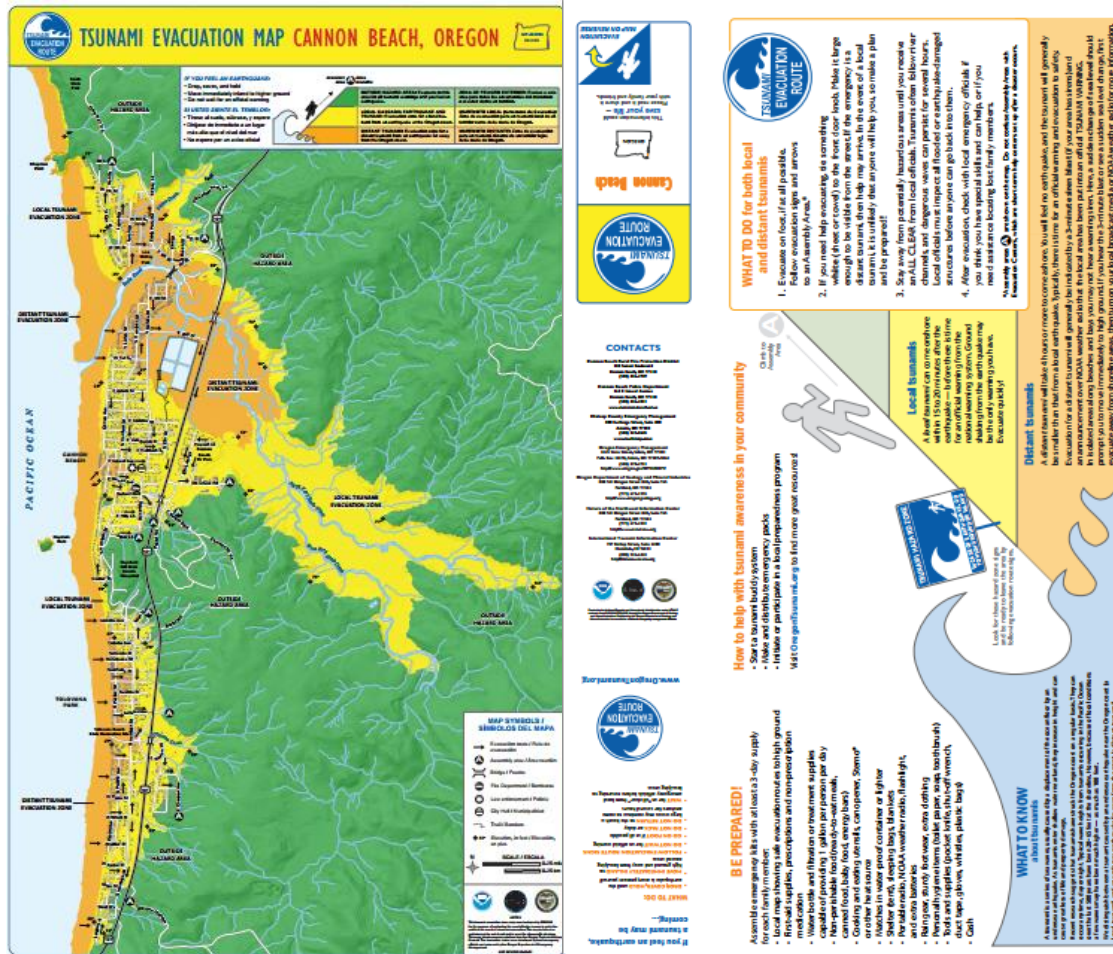


Fig. 24. The tsunami evacuation map brochure for Cannon Beach, Oregon (<http://www.oregongeology.org/tsuclearinghouse/pubs-evacbro.htm>).

With today’s technology, it is also possible to have online interactive maps showing the evacuation zones. A map viewer serving for this purpose is available through the website of the Oregon Tsunami Clearinghouse for the Pacific Northwest. As seen in Figure 25, the viewer enables the user distinguish between different tsunami regions (e.g. distant earthquake and tsunami vs. local Cascadia earthquake and tsunami) and search by address or coastal area. Also available is the mobile applications providing tsunami evacuation zones information. Such information system is of fundamental necessity for the public in case of emergencies.

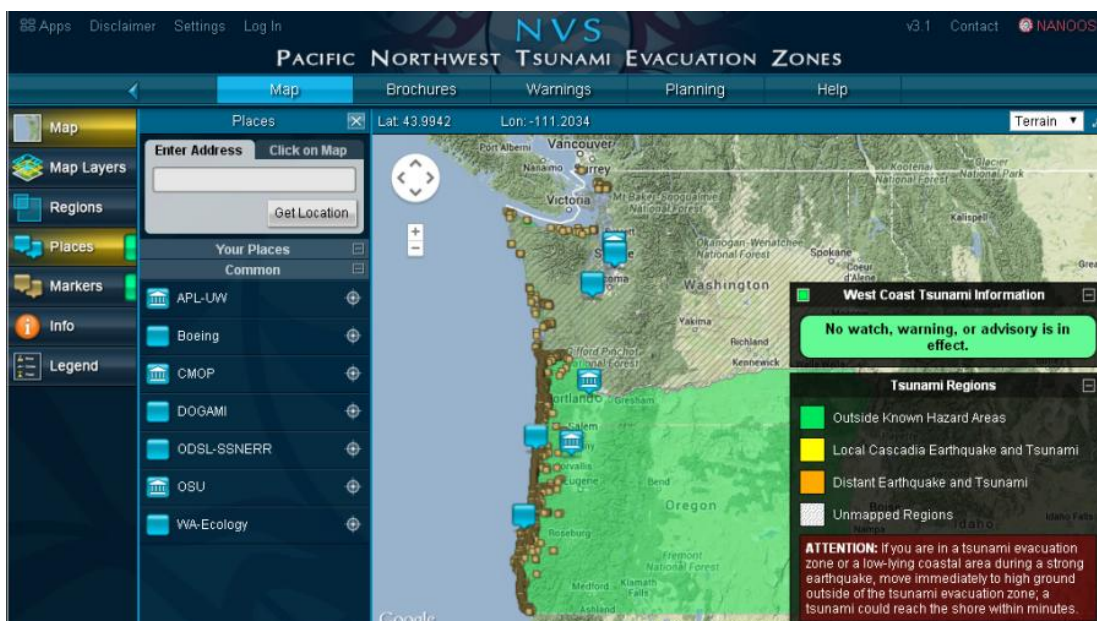


Fig. 25. The tsunami evacuation zone map viewer for the Pacific Northwest (<http://nvs.nanoos.org/TsunamiEvac>).

Raising awareness of and preparedness to tsunamis with the help of various educational materials and activities, as outlined here, should be the primary task of local authorities, and agencies responsible for hazard mitigation and emergency management. However, although there are many sources of information provided to people living in the communities at tsunami-risk areas, it is not clearly assessed whether this information (distributed through a variety of means) efficiently promote awareness and preparedness among the individuals. Dengler (2005) discusses the effects of tsunami education activities, materials, and programs – which are well-integrated within the National Tsunami Hazard Education Program (NTHMP; Dengler, 1998) of the United States as a primary tool for reducing the tsunami risk. Among the five Pacific States, the results obtained from the assessment surveys in Oregon, Washington, and Northern California show that tsunami awareness and recognition of tsunami hazards among the general public increased since the adoption of NTHMP. Nonetheless, the Washington study of Johnston et al. (2001) suggests that the public was not actively involved in taking actions to reduce their tsunami risk despite their increased awareness. The reason behind such lack of involvement might be due to their perception that tsunami hazard mitigation is a government activity.

In conclusion, it is important to employ a variety of educational materials and activities in attempt to build tsunami resilient societies. Furthermore, it is also of necessity to establish systems analysing effectiveness of these efforts, that is to say, how they lead to recovery. Accordingly, the existing system of efforts must be revised.

CHAPTER 3 PRELIMINARY CONCLUSIONS, GAPS IDENTIFIED AND RECOMMENDATIONS

Along with greater recognition and awareness of tsunami risk, building tsunami resilient societies has become an urgent need in most of the coastal communities all around the world, including the NEAM region. Promoting a culture of community resilience for tsunami disaster is, as such, a major concern. Despite the lack of an integrated and comprehensive understanding of community resilience in the context of natural hazards, the very term “tsunami resilience” should be based on such understanding. Hence this report, adopting a mature perspective on community resilience, is intended to provide a review on existing works concerning different aspects of tsunami resilience with a particular focus on preparedness and risk perception. Overall, the literature reviewed in this report has the potential to serve as a reference knowledge base for the subtasks 9.2, 9.3, 9.4, 9.5, and 9.6. The preliminary conclusions based on the literature reviewed in respect to the topics identified within the Task 9.1 of WP9 under the theme “building tsunami resilient societies” are as follows:

The overview of the literature indicates that related studies are less extensive on social science aspects of tsunami resilience compared to its technical aspects which are mostly dealt by engineers and scientists. It is important to emphasize that the concept of tsunami resilience is not solely associated to technical aspects, e.g. modelling efforts for tsunami hazard mapping and evacuation simulations. Considering the fact that community resilience accounts for certain aspects covering various social dimensions also, creation of tsunami resilient societies requires more research focusing on social science aspects of tsunami resilience. On the other hand, the already available literature is not well-focussed with regard not only to the terminology of interest, but also to the approaches employed. While much of the attention has so far been given to human/individual indicators (of tsunami resilience) with respect to coping skills and behaviour (i.e. preparedness), and cognition and knowledge (i.e. awareness, risk perception), the effects of various sociological dimensions (socio-demographic, socio-economic, social security, socio-spatial, political, and behavioural) on tsunami resilience has not been adequately explored yet. It should be noted that tsunami-specific literature on social science aspects has yet a lot to learn from the related literature on other natural disasters, e.g. earthquakes. In this respect, Task 9.2 of WP9 has great importance in building up the related literature considering aforementioned points especially.

The review carried out within the scope of this report also clearly points out the sparseness of the literature on tsunami crisis management. This situation raises the importance of the Task 9.3 “Crisis management assessment” for evaluating institutional and operational capacities of existing emergency response plans, and identifying both stakeholder and public needs. It is however essential that the findings from Task 9.2 are addressed in these efforts appropriately to ensure effectiveness within various components of tsunami crisis management.

Furthermore, the present literature definitely lacks an integrated understanding and assessment of community resilience to tsunamis. The available published literature on a broader context, however, is substantial enough to contribute and guide to future research for developing a resilience framework specific to tsunamis in the local context within Europe, which is one of the main objectives of WP9 of ASTARTE project. This framework should recognize tsunami-specific indicators of resilience – which are to be identified within WP9 subtasks for each of the case study site – in

addition to common indicators considered in the disaster research literature for other natural hazards. Conducting related research studies for WP9 on different case studies (test sites) will enable assessment of local differences with respect to different indicators. Accordingly, implementation of a case-study specific framework of tsunami resilience might be necessary.

Raising tsunami awareness and preparedness is fundamental for building tsunami resilient societies. The availability of educational materials and activities for communities facing tsunami risk is rapidly increasing especially with the help of Internet sources. However, effectiveness of these efforts must be analysed for gaining insight into the link between such efforts and achieved recovery level. The tools exemplified in this report (see Section 2.4) can serve as a model for the documentary film and leaflets to be designed in Task 9.5 of WP9.

The literature presented in Section 2.1 indicates a certain level of disorganization and a lack of integration to a great extent. This is clear from the fact that most of the studies do not give reference to tsunami-specific studies done to date. On the contrary, the literature reviewed in Section 2.3 is more organized and well-integrated.

Nevertheless, most of the literature reviewed in respect to the topics identified within the Task 9.1 is concentrated particularly on the Pacific & Indian region. It might be that the perception of negligible tsunami hazard in Europe as well as relatively frequent occurrence of large tsunamis in the Pacific & Indian region has restricted the attention devoted to research efforts so far. The NEAM region hosts many tourism destinations and the largest ports in the world, and consists of many coastal zones which are highly populated. Unfortunately, tsunami resilience has not been of considerable concern in Europe as compared to other tsunami-prone regions in the world. The project ASTARTE is therefore very much valuable for building tsunami resilient societies in general.

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