Guidebook

Planning for Tsunami Evacuations

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Planning for Tsunami Evacuations:
A Guidebook for Local Authorities and other Stakeholders
in Indonesian Communities

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1. Introduction

Surviving a tsunami is a matter of getting out of the reach of tsunami waves and inundating waters in time. To be able to escape tsunamis, people need to be aware of their personal risk and prepare to save themselves. Planning for tsunami evacuations is an important step to achieve this goal and to save lives.

The circumstances are challenging. Indonesian coastlines are threatened by local (or "near field") tsunamis that afford very little time for warning and evacuation. Quick reaction is needed. In such a situation, escaping a tsunami is primarily a matter of self-evacuation. After experiencing a strong earthquake, people should not wait for an official warning or a call for evacuation from authorities. Instead, they need to make the immediate decision to evacuate. Local emergency managers also must decide quickly whether to officially call for evacuation and notify their communities immediately. They rely on information from the Indonesian Tsunami Early Warning System (InaTEWS) and its National Tsunami Warning Centre at the *Badan Meteorologi, Klimatologi dan Geofisika* (BMKG, National Agency for Meteorology, Climatology and Geophysics), which provides tsunami warnings five minutes after an earthquake.

It must be expected that the earthquake will have already caused destruction, death and injuries in the area under tsunami threat. Local authorities and communities might be confronted with a chaotic situation, with electricity supply down and phone networks failing. Such adverse conditions and the short evacuation time do not leave many options for orderly evacuation support. Thus, it is essential that the population is able to react independently, but in an appropriate manner. That is where a local tsunami evacuation plan comes into play to provide guidance to the community at risk on how to prepare as a neighbourhood, but also as individuals, families or institutions.

"Planning for Tsunami Evacuations" is a guidebook for local authorities and other stakeholders in Indonesian communities that guides you in a step-by-step approach towards a tailor-made tsunami evacuation plan. The guidebook defines tsunami evacuation planning as the process of designing strategies, procedures and maps that enable and encourage people to evacuate in a timely manner. The main results of the planning process are a tsunami evacuation plan and public evacuation maps. The evacuation plan is a document that includes

a description of the local conditions, the evacuation strategy and procedures, evacuation maps, and recommendations for further steps that need to be taken to improve local tsunami preparedness.

The contents of this guidebook are based on experience with several evacuation planning processes in the GITEWS Pilot Areas between 2007 and 2010. Chapter 2 discusses important planning principles and assumptions. The core part of the guidebook is Chapter 3 that presents the five steps of tsunami evacuation planning. Chapters 4 and 5 provide references and a glossary. The planning steps are tailor-made for Indonesian communities that face a threat from fast-arriving local tsunamis. However, the guidebook can also support the design of evacuation plans for tsunamis that originate from a distant source ("far field" tsunamis).

Tsunami evacuation planning is part of local disaster management and the primary responsibility of local authorities. However, tsunami risk concerns everyone in a community; thus, everyone needs to be involved to reduce it. Bringing together representatives from all parts of the society in your planning process is the best way to find realistic solutions for tsunami evacuation that meet the needs of the people—so that some day, if a tsunami strikes your area, your community will be well prepared. This guidebook intends to support you in this joint effort.
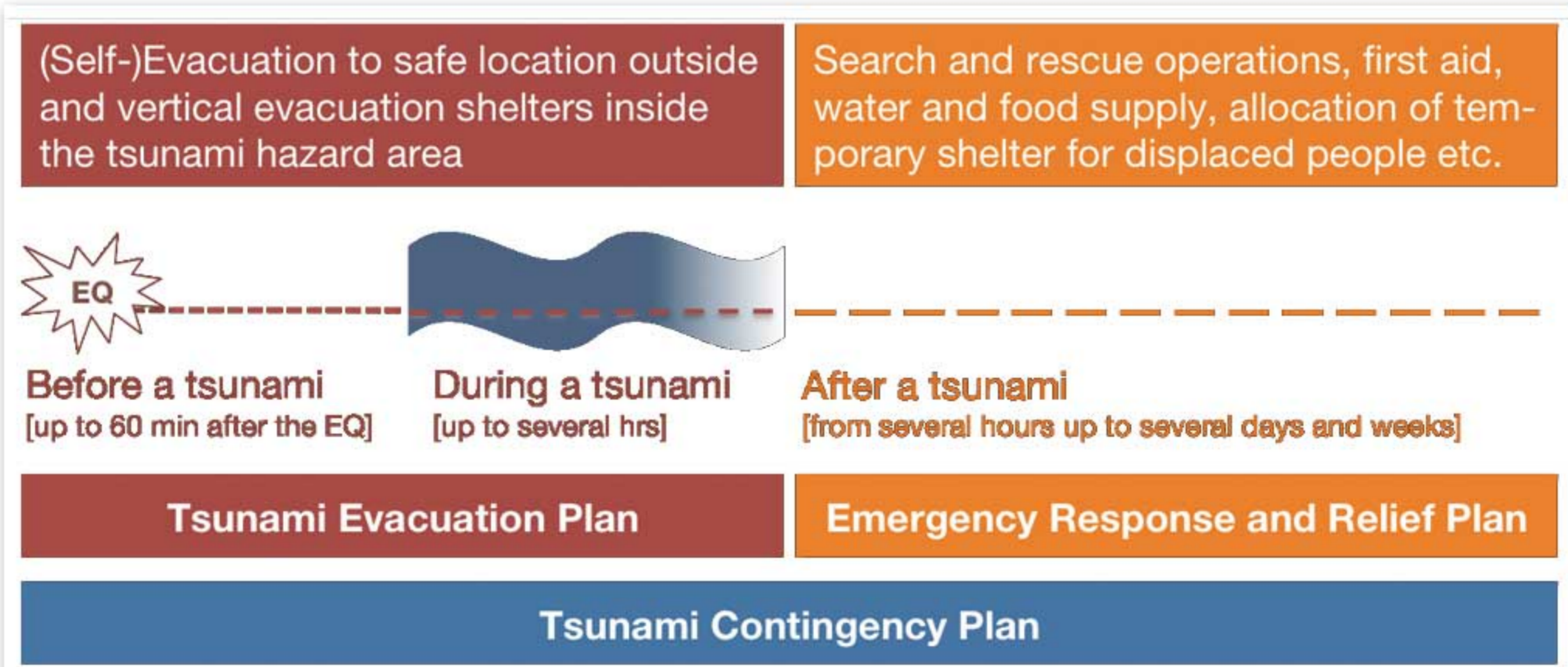
2. Planning Principles and Assumptions

Tsunami evacuation planning prepares for evacuations before and during a tsunami

Most tsunamis in Indonesia arrive quickly because they originate from earthquakes near the Indonesian coast. These local tsunamis leave little time for official warnings and evacuation. People need to start self-evacuation immediately after they feel a strong earthquake. Official warnings and guidance reinforce evacuation and notify people in case they did not feel the earthquake or believe they do not need to evacuate. Tsunami evacuation covers the time span from the moment of an earthquake until the immediate threat from tsunami waves is over, i.e., the last tsunami wave recedes and an "All Clear" message is received.

A tsunami evacuation plan is part of a tsunami contingency plan

Ideally, a tsunami contingency plan defines actions to be taken before, during and after a tsunami emergency. Compared to a tsunami evacuation plan, it also includes preparations for emergency relief operations after a destructive earthquake and a tsunami disaster. This guidebook can be used to produce tsunami evacuation plans that feed into tsunami contingency plans.

> According to the National Disaster Management Agency of Indonesia (BNPB), contingency planning is "a forward planning process, in the state of uncertainty in which scenarios and objectives are agreed upon, technical and managerial actions defined, and potential response systems and resource mobilization put in place in order to prevent, or better respond to an emergency or critical situation" (BNPB, 2008).

(Self-)Evacuation to safe location outside and vertical evacuation shelters inside the tsunami hazard area

Search and rescue operations, first aid, water and food supply, allocation of temporary shelter for displaced people etc.

EQ

Before a tsunami
[up to 60 min after the EQ]

During a tsunami
[up to several hrs]

After a tsunami
[from several hours up to several days and weeks]

Tsunami Evacuation Plan

Emergency Response and Relief Plan

**Tsunami Contingency Plan**

Tsunami evacuation planning as part of tsunami contingency planning

Evacuation planning requires a good understanding of your community's tsunami risk

Tsunami risk is the result of both a natural hazard, as well as a community's vulnerability to it and its capability to respond. The exact impact of a future tsunami cannot be predicted, but tsunami hazard assessments can provide you with an estimation of how high tsunami waters could be and how far they could reach inland. A hazard assessment also tells you how long a tsunami would need to reach your coast after an earthquake. All of this is important information that you need in order to define tsunami hazard areas that must be evacuated during a tsunami emergency and to determine safe areas. Tsunami evacuation planning cannot be done without this information. A communally approved and locally recognised tsunami hazard map is the best basis for tsunami evacuation planning.

This map shows probable tsunami inundation for the centre of the City of Padang, West Sumatra, based on the most probable worst-case scenario for the area. Highly resolved topography and bathymetry data, as well as sophisticated tsunami modelling was used to produce this map (Official Tsunami Hazard Map of the City of Padang, 2010; developed by Last Mile Evacuations Project, 2010).
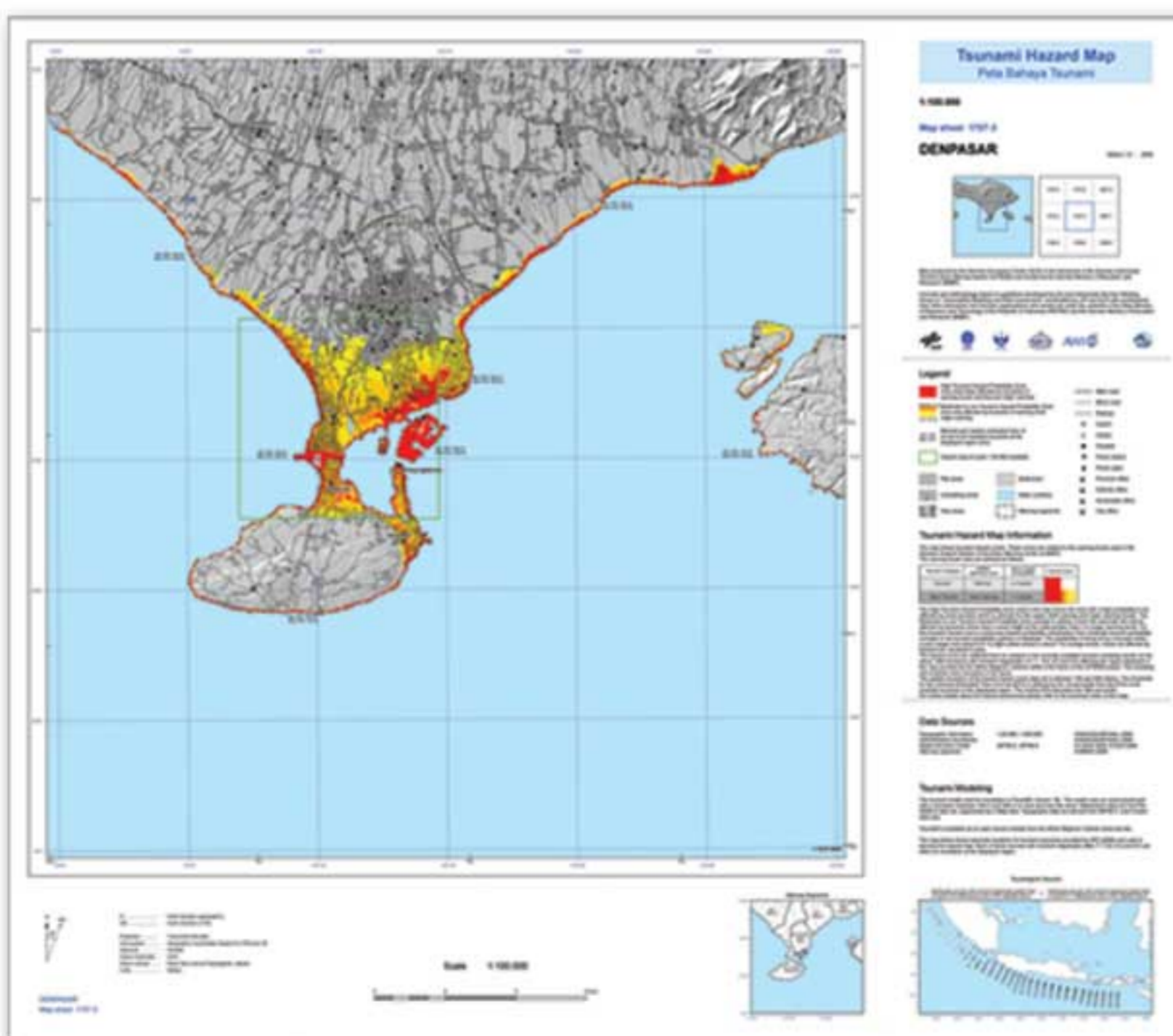
This map shows probable tsunami inundation by multiple tsunami scenarios along the southern coast of Bali. Areas in red indicate high probability for tsunami inundation while yellow areas have low probability of being hit by a tsunami. Highly resolved topography and bathymetry data and tsunami modelling was used to generate this map (Official Tsunami Hazard Map of Bali, 2009; developed by DLR-GITEWS, 2009).

TSUNAMI HAZARD MAP BANTUL DISTRICT
D.I. Yogyakarta Province
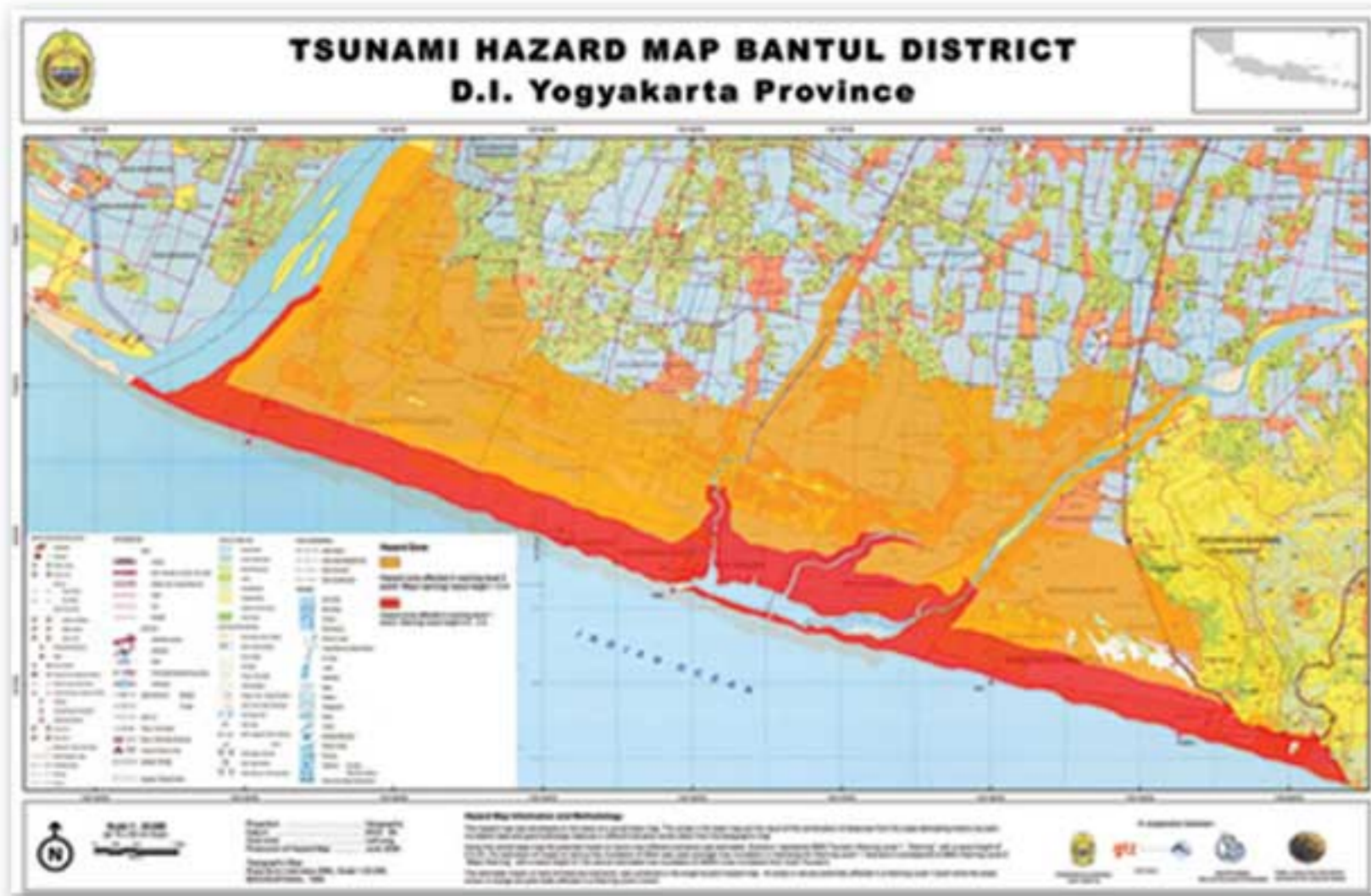
This map shows probable tsunami inundation in accordance to two threat levels for the District of Bantul, Yogyakarta. In the absence of highly resolved data and modelling results, the Tsunami Working Group in Bantul developed this map by using a simplified tsunami hazard mapping methodology. (Tsunami Hazard Map of Bantul District, 2008; support by GTZ IS-GITEWS).

A vulnerability assessment helps you to understand the capability and readiness of your community to respond appropriately to the tsunami threat, i.e., evacuate in time, and what needs to be done to prepare people for tsunami evacuations. Such an assessment examines how many people live in, or frequently go to, the hazard area, i.e., how many people and facilities are directly exposed to the tsunami threat and which groups and infrastructures are particularly weak in the face of the tsunami threat. It also tells you whether the local population understands their tsunami risk, knows natural warning signs, has access to official warnings, knows how to react adequately, and is able to find a safe place in due time. This helps you to determine the areas of high risk where people might not get a warning or will have difficulties leaving the hazard area in time. This information is crucial when defining evacuation routes, vertical evacuation shelters and additional warning dissemination channels and devices. An understanding of the social and cultural factors that influence people's readiness to evacuate helps you to continuously raise awareness of the tsunami risk and the appropriate way to respond to it.

Tsunami sirens, like the one in Seminyak, Bali, are the most effective tools for tsunami early warning. A three-minute steady sound of this siren means: immediate tsunami evacuation.


People who engage in activities directly on the coast, like fishermen, are particularly exposed to the tsunami threat, as they work and often live inside the tsunami hazard zone.

Official evacuation plans provide credible and binding reference

A tsunami evacuation plan should be acknowledged as an official government document. This makes it a credible and binding reference for institutions at all levels of government, NGOs, the private sector, and the local population. Once an evacuation plan is endorsed and widely disseminated, facilities such as schools, hospitals, hotels, etc., and communities can use these plans to develop their own evacuation procedures.

Deciding which administrative unit is most appropriate for such an official tsunami evacuation plan depends on the local conditions. In a rural area, an evacuation plan can be developed for the whole district and then serve as a reference for communities in villages who should develop their own procedures based on the official plan. In an urban agglomeration, such as those in southern Bali, you may produce an official plan at the sub-district level (e.g., *kelurahan*).
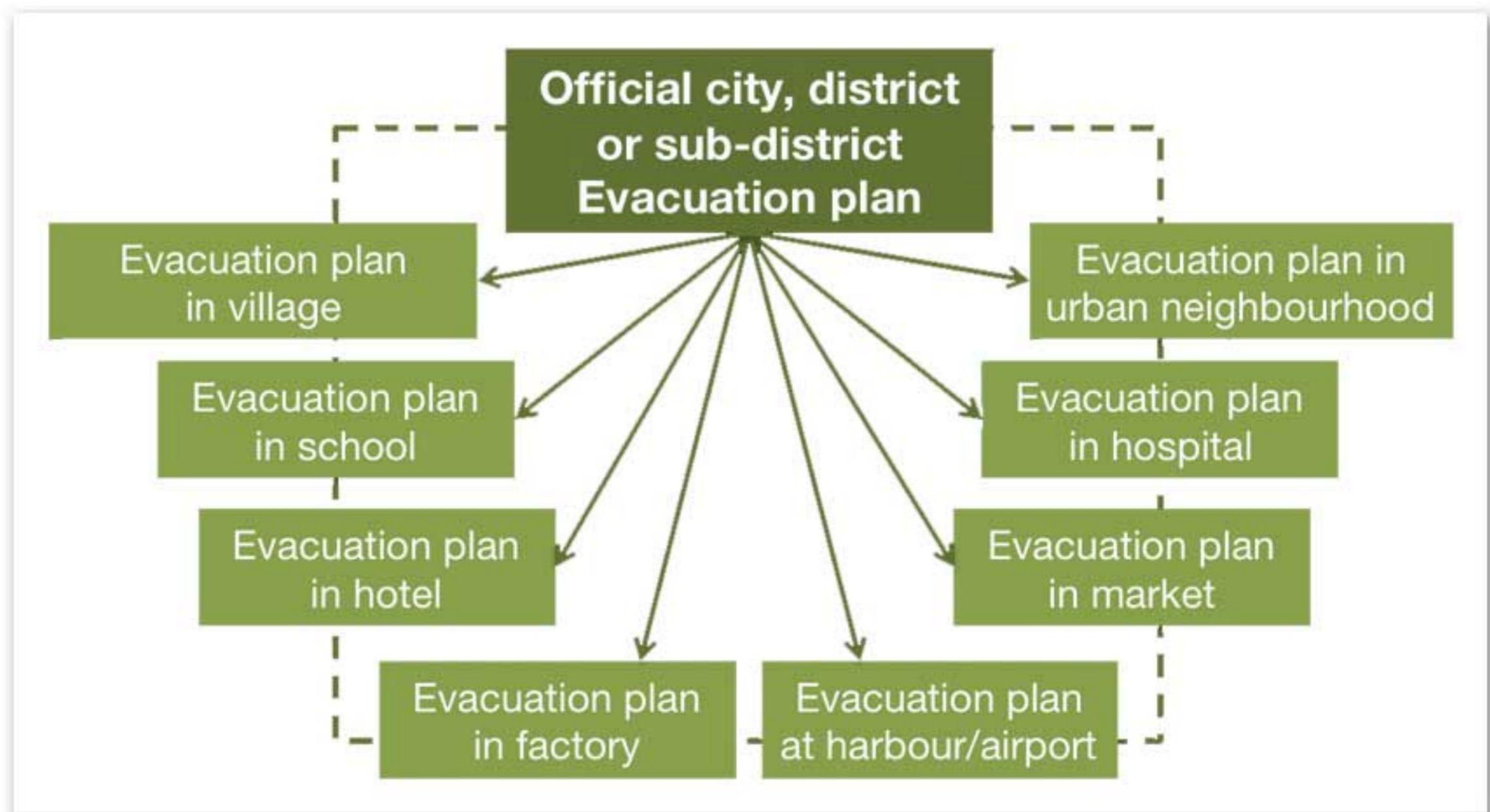
Official evacuation plans provide reference for communities and vulnerable facilities

Evacuation plans must be tailored to specific local conditions

The first priority in a tsunami evacuation is to get people away from the direct impact of tsunami waves close to the shoreline and out of the area that is subject to wave action and intensive flooding—the area that accounts for most victims during tsunamis. "Move away from the beach, inland and to higher ground" is a well-known piece of advice. Tsunami evacuation planning provides the opportunity to refine this strategy and adjust it to specific local conditions. Tsunami evacuation planning in a rural community might be a quick and easy exercise, whereas the development of a plan for an urban agglomeration might take considerable time and resources. For densely populated coastal plains—for instance, the City of Padang in West Sumatra or the Badung District in southern Bali—it must be assumed that not all people will be able to get out of the hazard area that may be flooded during a tsunami in time. Narrow street networks may cause congestion. Tsunami evacuation planning must indicate rela-

tively safe locations to provide evacuation options to those who are not capable of reaching safe areas further inland. These locations can be the upper floors of multi-storey buildings and natural land elevations inside the inundation area. A tourist destination needs specific evacuation procedures to meet the needs of its visitors, while an industrial area requires its own specific procedures, e.g., to prevent secondary hazards. Vulnerability assessments help to identify the characteristics of an area and contribute to appropriate solutions.

Evacuation planning must involve representatives from all parts of the society

Tsunami risk concerns everyone in a community. Thus, everyone needs to understand the risk and contribute to reduce it. Tsunami evacuation planning is comprised of various aspects, including the identification of local tsunami risks, the development of a realistic strategy, the identification of roles and responsibilities of local actors, and the dissemination and testing of the plan. Bringing together all relevant actors allows you to gather information and perspectives. A multi-stakeholder approach also provides the opportunity to create a common understanding of the risk and the need for action. Therefore, it is recommended to involve stakeholders from different segments of the society, including government institutions, formal and non-formal community representatives, the private sector, NGOs, and universities. Some representatives may be permanent members of the planning team, while others may be consulted at certain stages in the planning.

Evacuation plans must encourage people to take responsibility for their own safety

Evacuation in the face of local tsunamis is primarily a matter of self-evacuation upon experiencing strong ground shaking from a nearby earthquake. This means that people must evacuate without official evacuation instructions. People also cannot expect much direct support during evacuations since mobilising emergency responders takes time and sending them into the hazard zone for support means risking their lives. The most important support for your community is to make sure that people receive official warnings and evacuation guidance in time, understand them and know how to react independently to natural warnings and guidance, no matter whether they are at home, at the work place or in public spaces. You need to share the evacuation plan with your community and encourage people to prepare themselves and their families and take responsibility for their own safety. Once they understand the evacuation plan they can be encouraged to develop their own individual, family, neighbourhood, or institutional evacuation procedures. Community-based outreach programmes play a very important role in strengthening self-protection capacity.

Evacuation plans must inform people when to evacuate

Natural warning signs (primarily the earthquake), tsunami warnings from the National Tsunami Warning Centre at BMKG and guidance from local authorities notify people about an imminent tsunami threat. The authority to officially call for evacuation lies with the local government. Your tsunami evacuation plan needs to inform your community about the meaning of natural warning signs, how to get information from BMKG and the local authorities, and when and how to evacuate.

A "standard reaction strategy" that relates available information to the expected reaction may provide orientation to the community-at-risk and local decision-makers, and should be part of the tsunami evacuation plan. This reaction strategy combines reaction to ground shaking with reaction to warnings from InaTEWS. Depending on the level of the threat, BMKG issues different warning levels. Along the coast, however, both warning levels (i.e., "major warning" and "warning") translate into one action: evacuation, while an advisory from BMKG only means "moving away from the beach and river banks".

| Natural warning, official warning from BMKG and guidance from local authorities			Expected community reaction
EQ	If mild and short lasting ground shaking		Move away from beaches and riverbanks and search for information
	If strong and long lasting ground shaking: More than one minute, people are not able to stand		Evacuate hazard areas, move to designated safe location and search for information
5-10 min after the earthquake — Warning and guidance from local authorities *and* Warning and advice broadcasted by TV and radio stations	Major Warning	Evacuate immediately!	Evacuate hazard areas, move to designated safe location and search for further information
	Warning		
	Advisory	Stay away from beaches and riverbanks!	Stay away from the beach and river banks and search for further information
	EQ Info	No tsunami threat!	Return to normal activity (depending on EQ damage)

Standard strategy for community reaction to natural and official warnings and guidance

Experience shows that some people may not follow the plan...

It must be assumed that people will not always act as you may expect them to. Whether people are ready to evacuate depends on their knowledge and perception of their own tsunami risk and personal exposure, as well as the evacuation routes and safe places that can be reached in time. Still, some people may refuse to evacuate because they think they would not make it to a safe place in time; others may not believe in the warnings and rely only on retreating seawater as proof of an approaching tsunami. Some people might want to stay in their homes to secure their belongings. Many people will search for their relatives before they evacuate, which reduces their own evacuation time. Some people who evacuate may not go to the designated assembly areas, but rather will seek shelter with relatives and friends; others might even leave the area for a more distant location, because they are too afraid of aftershocks or tsunamis.

The only way to encourage people to follow evacuation procedures is to widely disseminate and explain the evacuation plan. Tests through tsunami drills or smaller evacuation exercises will help to prepare people for tsunami evacuations. Plans will be effective only if they meet the needs of the community.
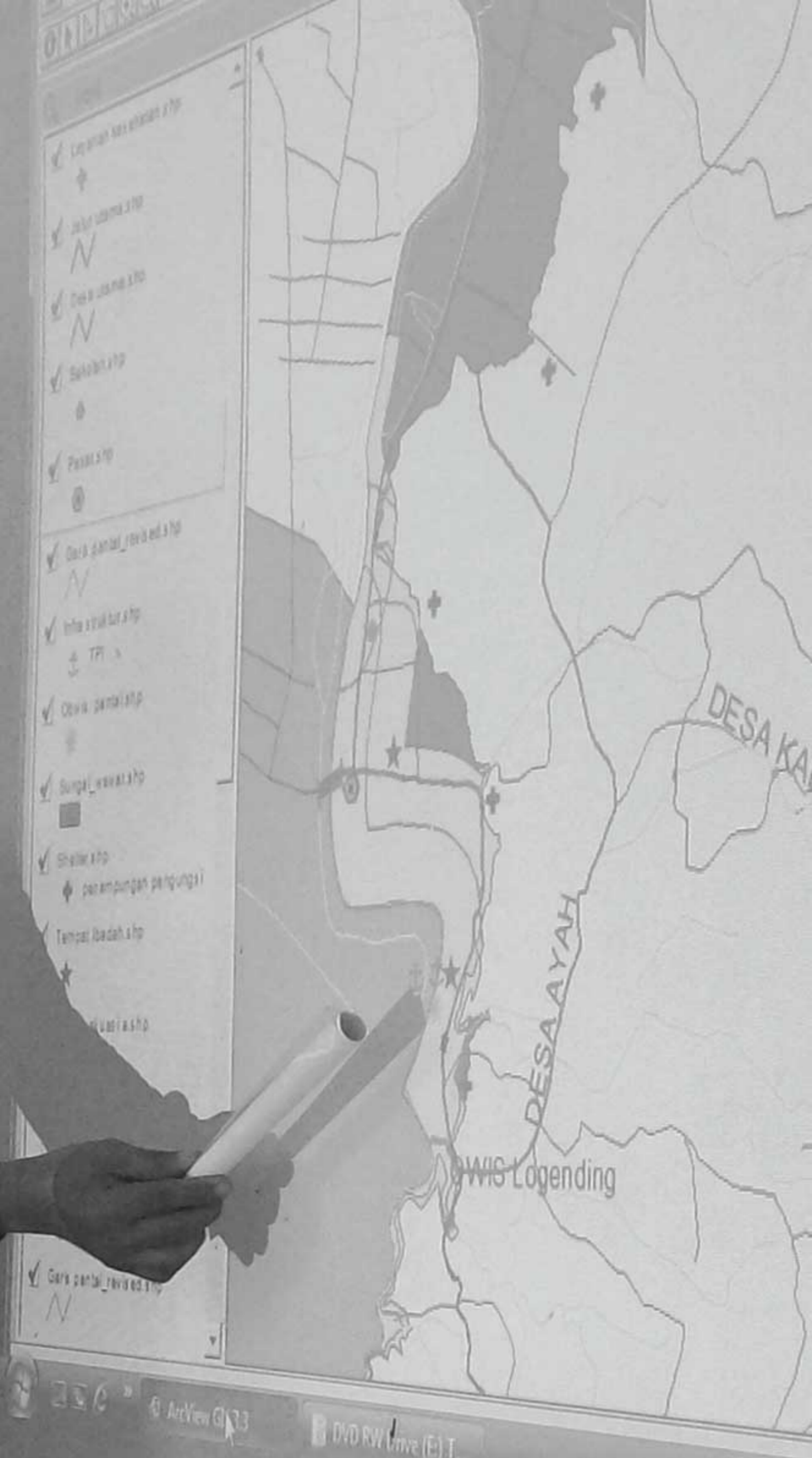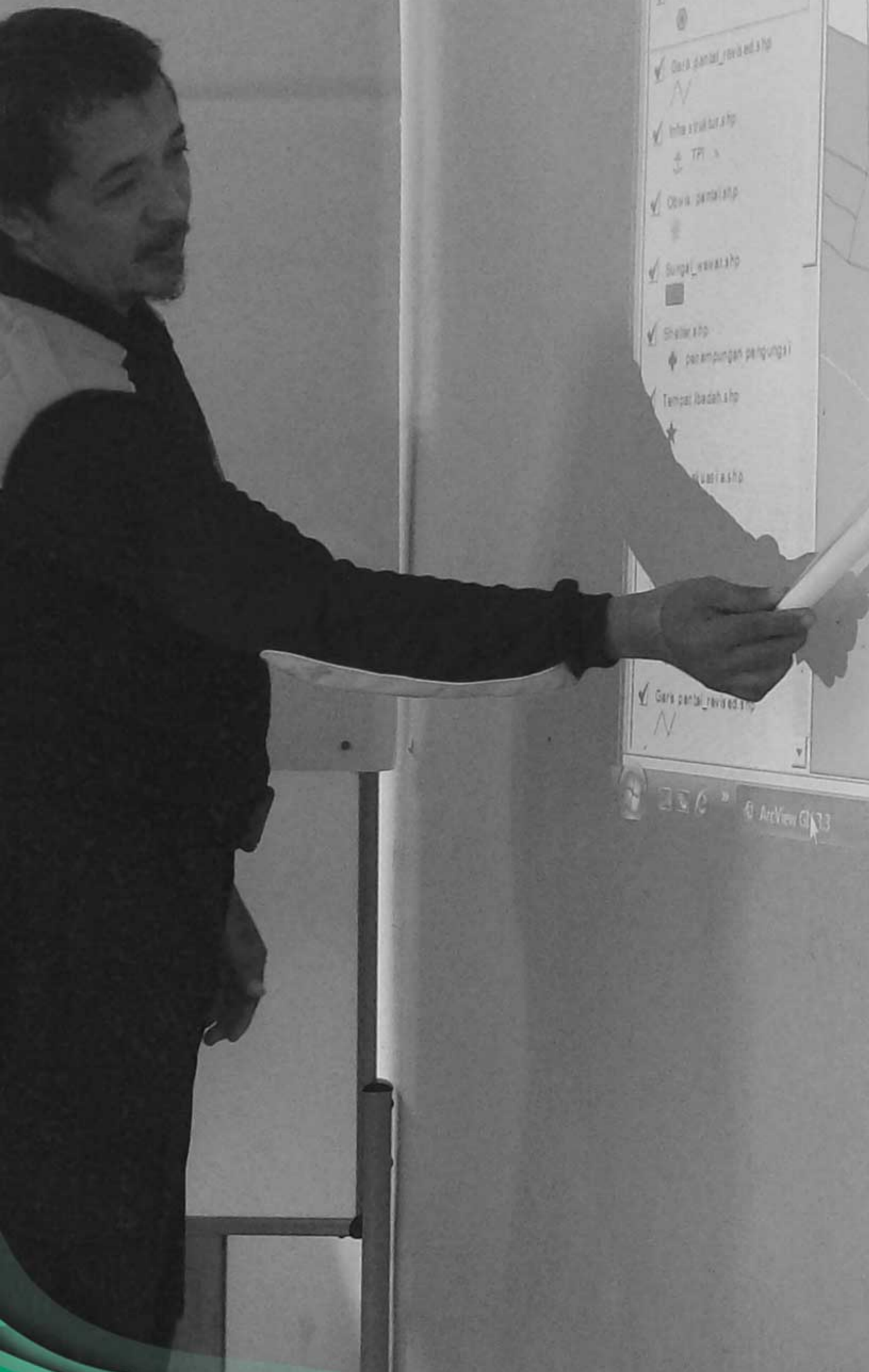
3. The Evacuation Planning Process

The following chapter presents the core part of the guidebook: a five-step method for tsunami evacuation planning. By following these steps you can design your tsunami evacuation plan, disseminate, test, and improve it.

The planning steps	Topics to be discussed	Output
Step 1: Prepare for the planning	Mandates, planning team and resource persons, data and information, resources, planning process and timeframe	Work plan
Step 2: Understand your community's tsunami risk	**Hazard**: inundation area and arrival time **Vulnerability**: physical exposure of population and facilities, capability to evacuate, preparedness and readiness to evacuate, early warning system Potential evacuation routes and shelter, high risk areas	Maps, data inventory, mind map, and assessment report
Step 3: Design your evacuation strategy and map	**Evacuation strategy**: evacuation time, evacuation zone(s), safe areas, assembly areas, modes of evacuation, evacuation shelter buildings, evacuation routes, when to (self-)evacuate **Support during evacuation**: traffic management, vulnerable facilities, evacuation signage	Preliminary evacuation plan: document that includes map, strategy and recommendations; draft public evacuation map
Step 4: Assess, endorse and disseminate your evacuation plan	Public assessment of the plan, endorsement by local authorities, dissemination to institutions and public, outreach strategy	Endorsed evacuation plan, dissemination and outreach plan
Step 5: Test, evaluate and improve your evacuation plan	Tsunami simulation exercises, means of observation and evaluation, revision of evacuation plan	Plan to test, evaluate and improve the evacuation plan

Five steps towards a tsunami evacuation plan

The overview chart shows the steps of the planning process, the topics you need to discuss, the data and information required and the output of each step. A work plan is the first output when you prepare for the planning process in Step 1. Preliminary maps, a data inventory and a mind map are the results of the discussions concerning your community's tsunami risk (Step 2). The output of Step 3 is a preliminary tsunami evacuation plan document that includes background information, your evacuation map and strategy, as well as recommendations for further steps. Another output is a draft public evacuation plan, including procedures. In Step 4, you assess the preliminary plan together with community members before you finalise, endorse and disseminate it. The output of this step is your endorsed

tsunami evacuation plan document together with plans to disseminate it and to conduct outreach activities. Through Step 5, you produce a strategy and plan on when and how to test, evaluate and improve the evacuation plan. All outputs of the planning process are described in greater detail at the end of the explanation of each planning step.

Often tsunami evacuation planners face difficulties because data that is considered important is not available. The most important information needed in the development of a reasonable evacuation plan is data on the tsunami hazard in your area and good knowledge about population density and distribution. If this information is available, then planning can begin. It is not recommended to delay the planning if you lack other information. You can always improve your plan once new and better data become available. Tests of your tsunami evacuation plan will help you to improve it even without additional data. Keeping your community prepared for tsunamis is a continuous process of raising awareness, reminding people of the threat, and updating and improving response strategies and evacuation plans. It is important to start now.

Evacuation planning team in Sanur, Bali

STEP 1:
Prepare for the planning

Before starting evacuation planning, there are several issues that need to be clarified. Answering the following questions will help you to organise the planning process and to get it started.

The issuance of an official tsunami evacuation plan is part of formal disaster management and, thus, government responsibility. There are several national regulations that make reference to the task of evacuation planning:

- Law 32/2004 on Regional Governance
- Law 24/2007 on Disaster Management
- Law 26/2007 on Spatial Planning
- Law 27/2007 on Coastal and Small Island Management
- Government Regulation 21/2008 on the Implementation of Disaster Management
- Regulation of the Ministry of Home Affairs 27/2007 on the Structural and Infrastructural Needs for Disaster Management, and
- Regulation of the Head of BNPB 4/2008 on the Guidelines for Disaster Management Plan Development

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These legislations state the official mandate and responsibility of district and city governments to issue evacuation plans. It is up to local governments to issue additional local regulations that further define roles and responsibilities for evacuation planning. This includes regulations on the implementation of tsunami early warning. Formally, it is the responsibility of the *Badan Penanggulangan Bencana Daerah* (BPBD, Local Disaster Management Agency) to take the lead in all issues related to disaster management and risk reduction. In case a BPBD has not been established in an area, this responsibility may still be with the ad-hoc disaster management body, *Satlak*, and its secretariat run by the *Badan Kesatuan Bangsa dan Perlindungan Masyarakat* (Kesbanglinmas, Local Civil Defence Agency). You need to clarify which local government institution has the mandate and means to take the lead—and is committed to take the initiative—in the planning process in your area.

Often initiative and advocacy for tsunami preparedness comes from civil society, e.g., representatives from NGOs or local universities who work in the field. They may take the initiative for, and lead, the evacuation planning process. However, close cooperation and coordination with local authorities is important to design official evacuation plans.

Who should get involved in the development of the evacuation plan?

Representatives from all parts of the society need to become involved in the development of a sound tsunami evacuation plan that serves the community. This includes representatives from government institutions, emergency responders, formal and informal community leaders and respected local figures, people from NGOs concerned with disaster risk reduction, and private sector actors, as well as local experts and professionals, e.g., experts from a local university. Bringing-together these people allows you to secure access to, and make use of, all available local knowledge and data that is required for an evacuation plan. It helps you to gather different perspectives and consider alternative solutions. Involving influential institutions and individuals in the planning adds credibility to your planning effort.

Some of these people will be part of the core planning team. This team often consists of only a small group of committed and knowledgeable individuals who have the time and resources to facilitate and implement the process from the beginning to the end. Others will be consulted at certain stages in the planning process. You need to agree on the roles and responsibilities of the stakeholders in the development of the evacuation plan and on effective ways to coordinate the effort.

Potential local stakeholders of tsunami evacuation planning

Government institutions	Non-government and scientific/academic institutions
BPBD (Local Disaster Management Agency) or Kesbanglinmas (Local Civil Defence Agency) BAPPEDA (Regional Planning Agency) POLRI (police) TNI (military) Fire brigade DEPSOS (Department of Social Affairs) DINKES (Department of Health) DISHUB (Department of Transportation) DEPDIK (Department of Education) PU (Department of Public Works)	PMI (the Indonesian Red Cross) SAR (search and rescue organisation) Beach and lifeguards (like *Balawista* in Bali) Other specific local rescue organisations Local NGOs concerned with disaster risk reduction Universities and schools
Community representatives and groups	**Private sector**
Kepala Desa/Lurah (village head) Kepala Dusun/RW/RT (representative of hamlets or neighbourhood units) Ketua Adat (traditional/customary leader) Religious leaders Traditional local security organisations RAPI / ORARI (Radio Amateur Associations) Women's groups (such as PKK) Other specific local community-based organisations and respected community figures	Hotels Tourism operators Markets/Malls Fishermen associations Other industries and business associations

National institutions that can provide input and assistance for tsunami evacuation planning

BNPB (National Agency for Disaster Management)
LIPI (Indonesian Institute of Sciences)
DKP (Department of Marine Affairs and Fisheries)
ESDM (Ministry of Energy and Mineral Resources)
Bakosurtanal (National Survey and Mapping Coordination Agency)

What kind of information is required—and what information is available?

To understand your tsunami risk and to be able to develop a sound tsunami evacuation plan, you need accurate data and information. In this Step 1 of the planning process you simply need to find out what information and data is available and who can provide it. In Step 2, the planning team reviews the information together with resource persons as required.

The data and information that you need falls into the following two categories:

1) *Data and information on your area's tsunami hazard*

   Tsunami hazard information is presented in tsunami hazard maps that show you which areas could be affected by a tsunami. Without this information evacuation planning is difficult. The best reference for evacuation planning is a tsunami hazard map that was developed by experts and is officially approved. However, there is no official map yet in many tsunami-prone areas of Indonesia. Non-official tsunami hazard maps can be used to plan for tsunami evacuations—however, you should request assessment by experts before you use them. Step 2 of this guidebook discusses tsunami hazard and provides you with further background information on tsunami hazard mapping and explains how to get to a reasonable tsunami hazard map if none is available.

2) *Data and information on your community's vulnerability to tsunamis*

   Analysing vulnerability means discovering the core weaknesses that make your community prone to loss of life and injury during a tsunami. There are two main reasons why people die or get injured when a tsunami hits their area: *people are not able to reach a safe place in time and/or they are not prepared and ready to evacuate*. Tsunami vulnerability assessments can explain these reasons in greater detail. However, there are only a few places in Indonesia, e.g., Cilacap (Central Java), Kuta (Bali) and Padang (West Sumatra), where tsunami vulnerability and risk assessments have been conducted and it is very likely that there are no such studies for your area (see Chapter 4 for reference to the results of the GITEWS Risk Assessments). If information is available for your community, gather and review it. If not, you can collect information yourself.

   In order to know whether *the people in your community are able to reach a safe place in time*, you first need to find out how many people in your community are actually exposed to the tsunami hazard, their spatial distribution and who these people are. This means information on how many people live in, or frequently go to, the tsunami hazard area and what facilities may be particularly vulnerable. The following information is important:

- Population data that helps you determine your community's population numbers, density and spatial distribution (e.g., census data from the statistics department, BPS; and/or data from village or *kelurahan* representatives),

- Topographic maps from Bakosurtanal on a scale of 1:25,000 that show your area's elevation, land use, spatial distribution of settlements, and infrastructure,

- Data on size and location of facilities, such as schools, kindergartens, universities, training centres, hospitals, markets and malls, hotels, tourism and recreation sites, mosques, churches and temples, community centres, larger government and non-government offices, detention centres, industrial sites, harbours, bus terminals and airports, and other facilities where many people gather that require special attention in the planning and during evacuations. When collecting this data try to determine whether these facilities already have special procedures, evacuation plans and means for tsunami warning dissemination in place.

Whether *people in your community are prepared and ready to evacuate* depends on whether they understand the tsunami risk, are aware of their personal exposure and whether they perceive it as a serious threat. It also depends highly on whether people know natural tsunami warning signs and how to react to them. If there are no studies on these issues in your area, experience from other tsunami-prone regions in Indonesia may help you to understand key factors that determine a community's tsunami preparedness and readiness to evacuate. Step 2 of this guidebook tells you more about it and gives you hints on how to conduct your own studies.

Your community's preparedness and readiness to evacuate in time also depends largely on whether people receive a warning in time. In Indonesia, official tsunami warnings are provided by InaTEWS and are disseminated by BMKG in Jakarta via national TV and radio stations. Everyone who receives this public notification can (and must) forward it to others. Local authorities of districts, cities and sometimes provinces are obliged to use this warning to provide their communities with instructive and timely guidance on what to do. Only they have the official mandate to call for evacuation. Your evacuation plan needs to include information on the local tsunami early warning arrangements. Make sure you collect the following information on procedures, roles and responsibilities, as well as technical aspects with regards to tsunami early warning in your area:

- Local institution with the mandate to issue official warning and guidance, including an official call for tsunami evacuation,
- Local regulations on disaster management and tsunami early warning,
- Other institutions in your area that forward warnings from BMKG and official guidance from local authorities,
- Institutional Standard Operating Procedures (SOPs) for quick decision-making (whether to call for evacuation or not) and disseminating tsunami warnings and guidance,
- Coverage with tsunami sirens,
- Coverage with public loudspeakers (e.g., at mosques or other public places) that are used to announce official warnings and guidance,
- Frequencies and coverage of public radio and TV stations that broadcast warnings and guidance,
- Frequencies and coverage of public and internal radio communication networks that are used to disseminate official warnings and guidance,
- Traditional means of communicating warnings in your community.

What other resources are needed?

Tsunami evacuation planning does not have to be expensive. You can minimise the costs by using local resources, encouraging voluntary participation and asking for contributions from the private sector. The major share of the expenses for tsunami evacuation planning, however, should be covered by the budget allocated to the local government institutions in charge of disaster management. You need to discuss budget planning and sharing amongst the involved institutions.

The main resources for tsunami evacuation planning are the people who become involved—their time, knowledge, ideas, and commitment. The core planning team usually consists partly of government officials who are in a paid position. Make sure that for those officials involved, the planning is part of their regular duties. Other members of the core team may come from organisations, such as the Indonesian Red Cross (PMI) or Search and Rescue (SAR), which have a strong sense of voluntarism and share an interest in disaster preparedness. They might join in without any request for remuneration. Representatives from local NGOs that run disaster preparedness programmes might have a shared interest too and may be willing to join on a voluntary basis as well. If they understand the tsunami risk and take it seriously, experience shows that traditional, religious and formal community representatives understand the benefits of joint efforts for their community and are willing to contribute their time and expertise.

Nevertheless, you need to prepare a budget estimation that covers the following expenses:

It is customary that meals, snacks and drinks are offered during meetings—no matter whether they are small meetings or larger community gatherings. As the planning process requires several meetings, you need to agree on who can provide the meeting venue and serve refreshments. Cost sharing is always an option. As all activities are conducted locally, transportation costs should be minor.

Depending on the data already available, considerable costs may result from generating additional information on tsunami hazard and vulnerability. When using local resources and involving local expertise, costs can be minimised. Whether there is a need to conduct additional assessments will become clearer during Step 2 of this guidebook.

The planning team will produce maps to visualise the results of the discussions. This involves printing costs. Depending on the skills and resources available locally, the mapping may be done manually or by using GIS tools.

You need to plan some budget for the dissemination of the evacuation plan to institutions and the general public. Costs will occur from the printing of the tsunami evacuation plan, evacuation maps, information leaflets, and production of evacuation signage, as well as the installation of additional warning dissemination devices. The funds needed for these investments will become clearer when conducting Steps 3 and 4 of this guidebook.

How long does it take to develop a tsunami evacuation plan?

How long it takes to design a good evacuation plan depends primarily on the complexity of the area, commitment and time of the people involved and the information available. Producing a plan for a rural area with few settlements takes less time than making one for a densely populated urban area. An evacuation plan is a "living document" that needs to be tested and improved once new data is available or if conditions change. Experience shows that if all data is available you might be able to develop a solid evacuation plan within half a year. Then you need to test it and revise it. After one year you might have an improved plan. This, of course, works only if you can assure a strong commitment from all stakeholders and the resources necessary. It is up to the planning team to set a deadline for the presentation of the final plan. Make sure that the planning team agrees on a realistic timeline. This helps to keep on track and moving.

What are the steps and output of the planning process?

To get to a common understanding of the planning process, the planning team needs to discuss the steps, objectives and output in an initial preparation meeting. The chart on the planning steps in the beginning of Chapter 3 provides you with an overview. You can break down your time frame and meeting schedule in accordance to the five steps and agree on results that you want to achieve in a certain amount of time. At the same time, you may clarify roles and responsibilities in fulfilling the various planning tasks.

Output of Step 1: work plan

You have taken an important first step towards better tsunami preparedness! We recommend that you document all agreements and conclusions from your discussions in Step 1 in a simple, but complete, work plan. This work plan guides you through the planning process and keeps everybody on track. An effective work plan is agreed upon by all stakeholders, defines realistic objectives and output, defines roles and responsibilities, sets the time frame, and indicates the resources required to accomplish it.
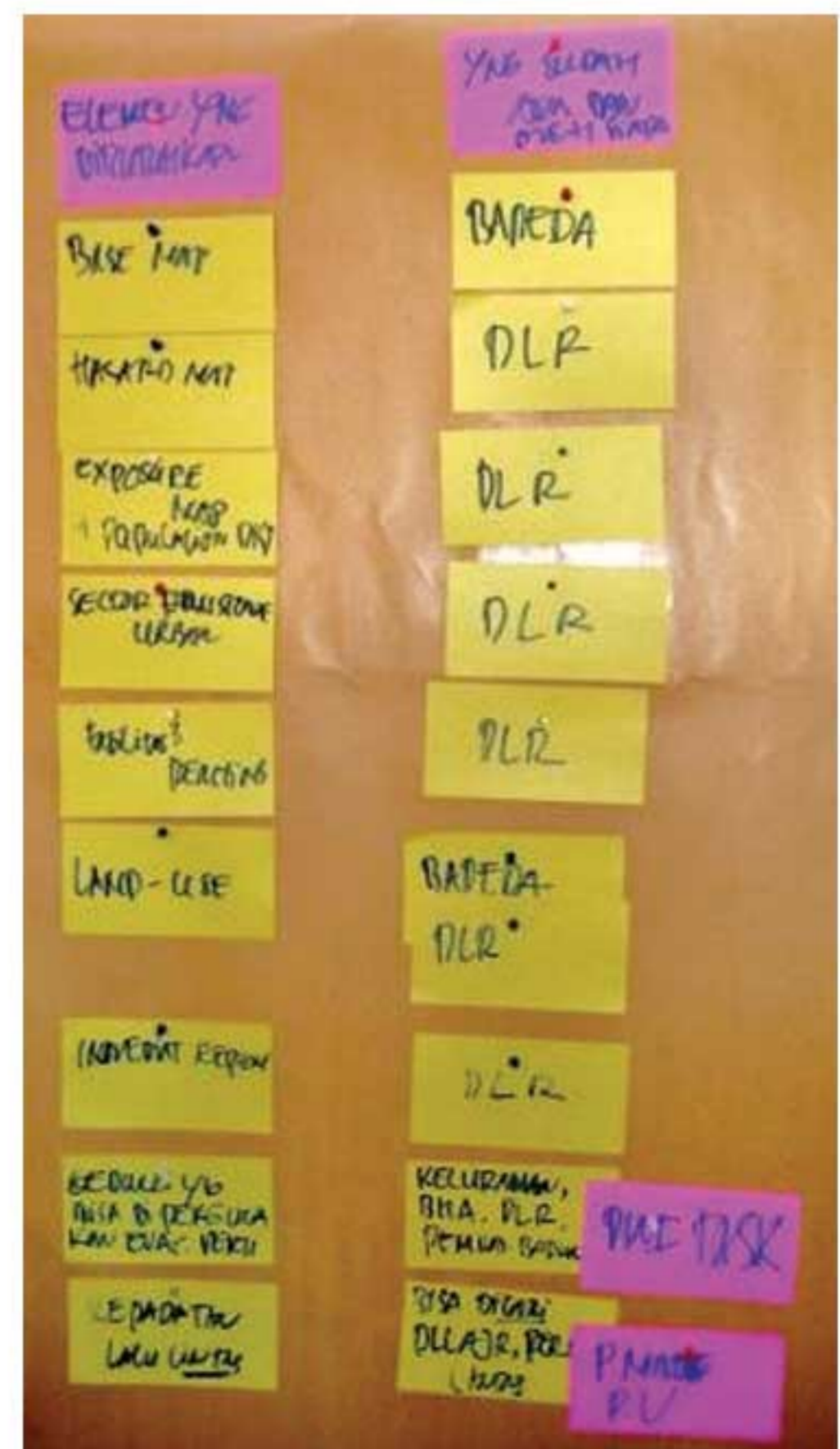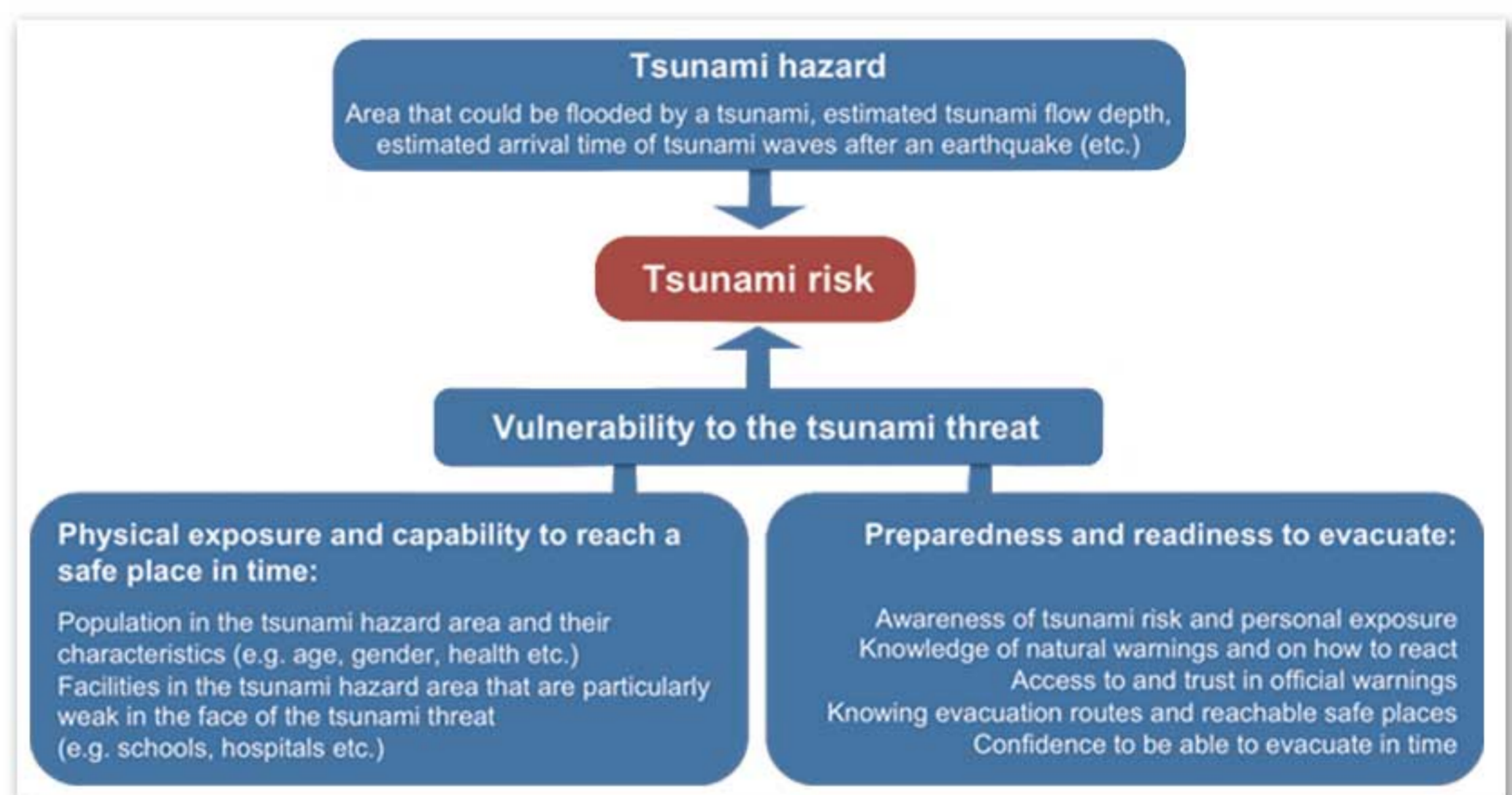
Work plan of evacuation planning team in Kelurahan Kuta, Bali (left) and list of required information regarding local tsunami risk (right)

STEP 2:
Understand your community's tsunami risk

It is now time to take a close look at the data and information you collected. Step 2 guides you in organising and mapping the information on your area's tsunami hazard and your community's vulnerability to it. This section also offers you means to generate urgently needed information and provides background knowledge for your planning.

You may not have been able to obtain all the data and information indicated in Step 1. While it is not recommended to delay evacuation planning because of missing information, there is some information that you do need for planning to continue: a reasonable tsunami hazard map and a topographic map of your area. Your own knowledge of the area and that of other resource persons you may invite to join the planning process can fill in other information gaps.

Tsunami hazard
Area that could be flooded by a tsunami, estimated tsunami flow depth, estimated arrival time of tsunami waves after an earthquake (etc.)

Tsunami risk

Vulnerability to the tsunami threat

Physical exposure and capability to reach a safe place in time:

Population in the tsunami hazard area and their characteristics (e.g. age, gender, health etc.)
Facilities in the tsunami hazard area that are particularly weak in the face of the tsunami threat (e.g. schools, hospitals etc.)

Preparedness and readiness to evacuate:

Awareness of tsunami risk and personal exposure
Knowledge of natural warnings and on how to react
Access to and trust in official warnings
Knowing evacuation routes and reachable safe places
Confidence to be able to evacuate in time

Tsunami risk is the result of tsunami hazard and a community's vulnerability to it

Understand your area's tsunami hazard

A tsunami hazard map shows areas that a tsunami could affect (see maps in Chapter 2). It enables you to define tsunami hazard zones that could be flooded and safe areas where no flooding from tsunamis is expected. Some tsunami hazard assessments provide the estimated arrival time of a first tsunami wave after an earthquake. This time depends mainly on the distance of an earthquake's location from your coastline and the structure of the sea floor. In Aceh, for instance, the first tsunami wave arrived within about 20 minutes of the earthquake on 26 December 2004. This time may vary for your area, but is for most tsunami-prone areas of Indonesia usually not more than 30 minutes. Some islands that are located close to earthquake source areas may expect waves to arrive even faster (IOC, 2009c).

The estimated arrival time is very important information because it determines the time your community has to reach a safe place after an earthquake occurs. If your map does not provide this information, try to get it from those who produced the map or refer to recorded arrival times from previous tsunamis in your region.

Keep in mind that there are different ways to produce tsunami hazard maps. It is important to know how a tsunami hazard map was made to understand what it actually shows. Tsunami hazard maps can be the result of either highly scientific or simplified hazard estimations:

- Scientists use tsunami propagation and inundation modelling to analyse the tsunami hazard. They model the sources of tsunamis, e.g., a submarine earthquake, how the waves travel in the ocean and how they behave when they reach the shore and flood coastal areas. This results in an inundation area on land and other information, including tsunami arrival times. The modelling of the tsunami hazard requires accurate (and often expensive) data on topography and bathymetry (i.e., the structure of the sea floor) and accurate information on the tsunami sources (i.e., seismic and tectonic data). These kinds of hazard estimations can be done for a probable "worst case" (single scenario approach) or several earthquake and tsunami scenarios that are likely to occur (multi-scenario approach).

- Simpler hazard analysis is based either on historical tsunami events in a particular area or evidence of tsunami inundation from other places in the region. Both references can be used to define tsunami hazard areas. The information needed is the maximum height and inundation area of a previous tsunami. Besides information on the height and inundation area of historical tsunamis, both approaches require reasonable topography and elevation data. Arrival times for tsunamis that occurred not too long ago may be available as well.

Nearly all of the more sophisticated tsunami hazard maps distinguish between different hazard zones, usually indicated by different colours or shading. Single scenario maps often distinguish areas of high, moderate and low hazard. Areas close to the coast will suffer the strong and destructive physical impact of the waves (impact zone), whereas areas further inland will "only" be flooded (inundation zone). Multi-scenario maps indicate the probability of a certain area to be hit by various possible tsunamis and distinguish between areas of high, moderate and low probability. It is important to understand the meaning of different zones in tsunami hazard maps, as they are important when defining evacuation zones.

What to do if you doubt your tsunami hazard map's quality or if there is none at all?

Tsunami hazard maps are the major reference for tsunami evacuation planning. District and city governments are in charge of producing tsunami hazard maps in cooperation with experts. Tsunami evacuation planning without a reasonable tsunami hazard map is not recommended. If your map has not been officially endorsed or you doubt its quality, it is recommended to consult with experts on whether the map is reasonable. Professional advice can be found at local universities or with national institutions (see below). In case there is no reasonable tsunami hazard map for your area, you will need to produce one.

You may consider three options to obtain a reasonable tsunami hazard map:

1) First, contact universities or other professional institutions in your region that deal with disaster risk reduction and find out whether a hazard analysis for the local coast has been done or is planned. Often assessments are conducted, but the results do not reach those who need them. You may also consider contacting the following national institutions: Bandung Institute of Technology (ITB), Agency for the Assessment and Application of Technology (BPPT), Indonesian Institute of Sciences (LIPI), Department of Marine Affairs and Fisheries (DKP), National Agency for Meteorology, Climatology and Geophysics (BMKG), National Agency for Disaster Management (BNPB), and the Ministry of Energy and Mineral Resources (ESDM). These institutions may have tsunami hazard maps for your area, plan to conduct an analysis or be able to get you in contact with others who do have the needed maps. The GITEWS project also developed tsunami hazard maps for large parts of the Indian Ocean coast of Indonesia (see Chapter 4 for further reference).

2) If you do not succeed with the first option, you can produce a tsunami hazard map yourself. The GTZ IS-GITEWS project developed a simple tsunami hazard mapping methodology that was applied in five districts along the southern coast of Java in 2007, 2008 and 2010. You can download the guidebook "Where is the Safe Area?" from the website: www.gitews.org/tsunami-kit, together with a report on lessons learnt from the latest application in 2010. The methodology used data on historical tsunami events and tsunami experiences from all over Indonesia, topographic and geomorphologic features derived from *Bakosurtanal* maps and local knowledge to determine tsunami hazard areas. It is recommended to involve local experts (e.g., a local university's faculty of earth science or planning) who have an understanding of hazard assessments. Experience shows that it may take up to six months to produce a reasonable tsunami hazard map.

3) The guidebook, "Prepare your Community for Tsunamis", by Geo Hazard International also offers ways to get to a reasonable tsunami hazard and evacuation map. The Intergovernmental Oceanographic Commission (IOC) compiled a guidebook on tsunami hazard and risk assessment. Unfortunately, both guidebooks are available only in English. They can be downloaded from the Internet (GHI, 2008; IOC, 2009b; see Chapter 4).

Data sources for tsunami hazard mapping on the Internet

Accurate elevation data is key when mapping tsunami hazards. The links below (in English only) are public resources where you can download this data. You may need to consult an expert regarding utilisation and processing of this data:

- SRTM (Shuttle Radar Topography Mission): http://srtm.csi.cgiar.org

- ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer): http://www.gdem.aster.ersdac.or.jp/index.jsp

- GEBCO (General Bathymetric Chart of the Oceans) provides bathymetry data of the world's oceans: http://www.bodc.ac.uk/data/online_delivery/gebco/

The website of the United Stated Geological Survey (USGS) provides data on prediction and probability of future earthquakes: http://www.earthquake.usgs.gov/earthquakes/ (click on the links under the section 'Future').

Understand your community's vulnerability to the tsunami threat

Two main aspects influence the vulnerability of your community to tsunamis: people's exposure and capability to reach a safe place in time and/or people's preparedness and readiness to evacuate. The following section discusses both aspects separately although you will see that they are very much interrelated. Besides the tsunami hazard map and the time available for evacuation, your community's exposure and its capability to reach a safe place in time is the most important aspect that you need to consider in developing a reasonable tsunami evacuation map (in Step 3). Understanding people's preparedness and readiness to evacuate is important when improving your local tsunami warning system (in Step 3) and developing appropriate awareness campaigns and outreach activities (in Step 4).

If not already a part of the planning team, you may invite representatives from relevant government departments, NGOs, private sector associations, and universities to join you in reviewing the data and information. Knowledgeable people, including community representatives who know the area, its population and infrastructure, are valuable resource persons in this step as well.

Physical exposure and capability to reach a safe place in time

How many people are exposed to the tsunami threat?

A tsunami that hits an uninhabited island somewhere in the ocean will not cause a disaster, but the same tsunami hitting a densely populated coastline may result in a huge loss of human life. This means a tsunami risk exists only if people are exposed to the hazard because they live in or frequently go to the area along the coast that could be affected by a tsunami. The first thing that is important for

you to look at is how many people are exposed and could be potentially affected by a tsunami because they live, work or spend time in the tsunami hazard area. This number may differ between day and night times. Some areas with few residents are busy during the day, but rather deserted at night; others are residential areas that people leave during the day to work elsewhere, but come back to in the evening. It is recommended to consider the worst-case scenarios in your planning, i.e., the time when most people are exposed.
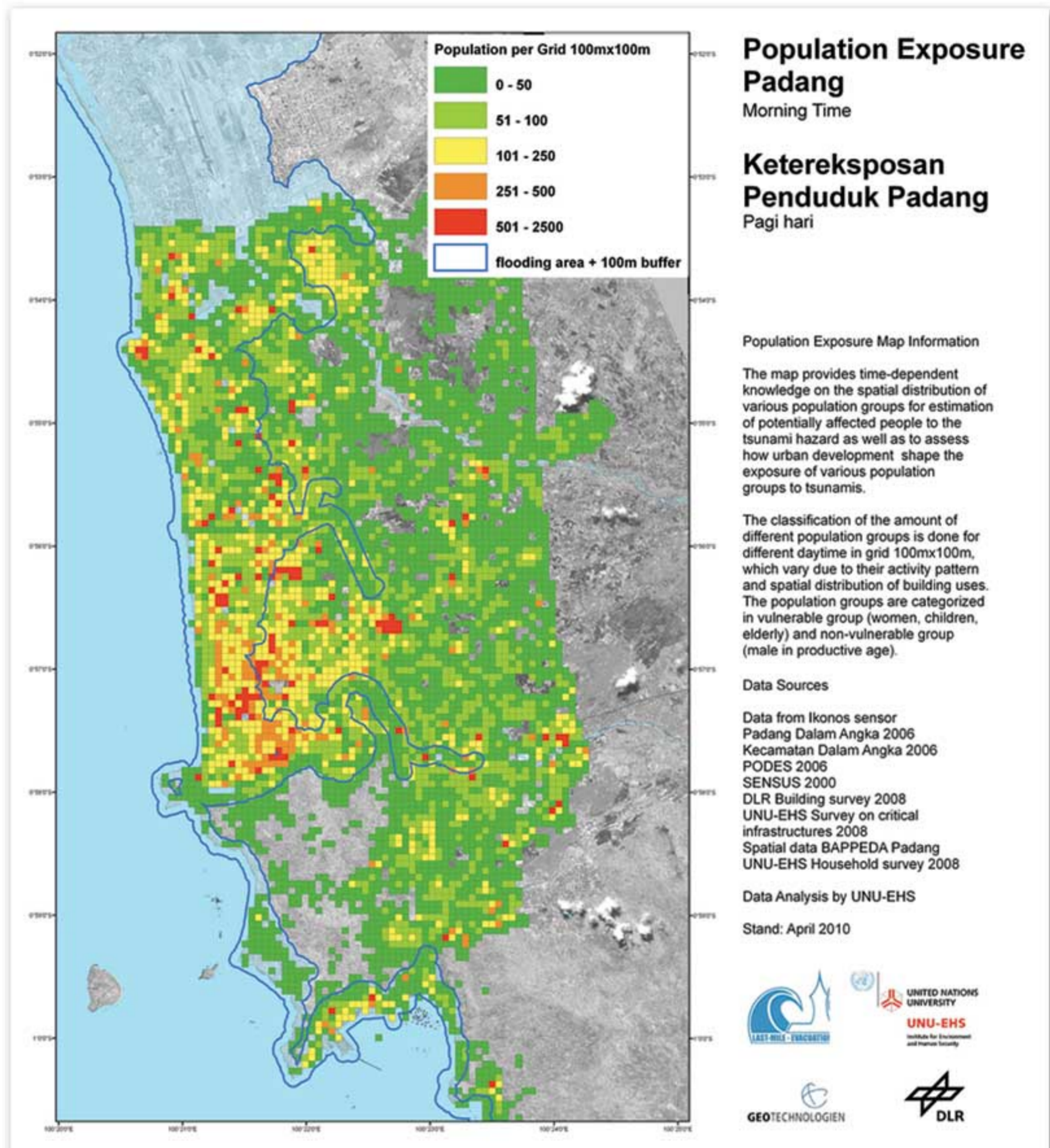
This map shows the spatial distribution of the population of Padang (West Sumatra) and its density inside the tsunami hazard area during morning hours and, thus, the population that is exposed to the tsunami threat. If available, such maps that are developed by experts can help you to determine areas with high population densities that require special attention during evacuation planning. They can also be a good tool to raise awareness amongst local decision-makers in showing how many people could become victims of a tsunami and the urgent need for preparedness (Last Mile Evacuation Project, 2009).

The tsunami hazard map defines the tsunami hazard area. Depending on whether you are able to use GIS, you can digitally overlay the area that would be inundated by a tsunami with your topographic map

or simply draw the line of maximum inundation onto your topographic map. By using the population data of your area you can now (digitally or manually) record the number of inhabitants of a sub-district, village, hamlet, or *kelurahan* on your map. It may be helpful to create an inventory of the population data by administrative unit. This will give you an overview of the spatial distribution and density of your population inside the tsunami hazard area.

Some people are less capable to evacuate and more likely to become victims than others

Experience from the devastating tsunami in 2004 shows that women and young children account for most of the tsunami victims (IOC, 2009b). Children's small body mass and their lack of physical strength means that they can be more easily carried away by tsunami waters as they are less able to grasp fixed objects, such as trees. Like children, women may have less physical strength than men. Women may also be in charge of taking care of the children. In a tsunami they have to save themselves and help their children at the same time. In addition, learned skills tend to differ between women and men. Boys are often better at running, climbing and swimming than girls, as these activities may not be considered appropriate for females in the local culture. Elderly, sick and handicapped people also lack these abilities and physical strength, which make them more prone to injury or death during a tsunami and less capable to evacuate quickly.
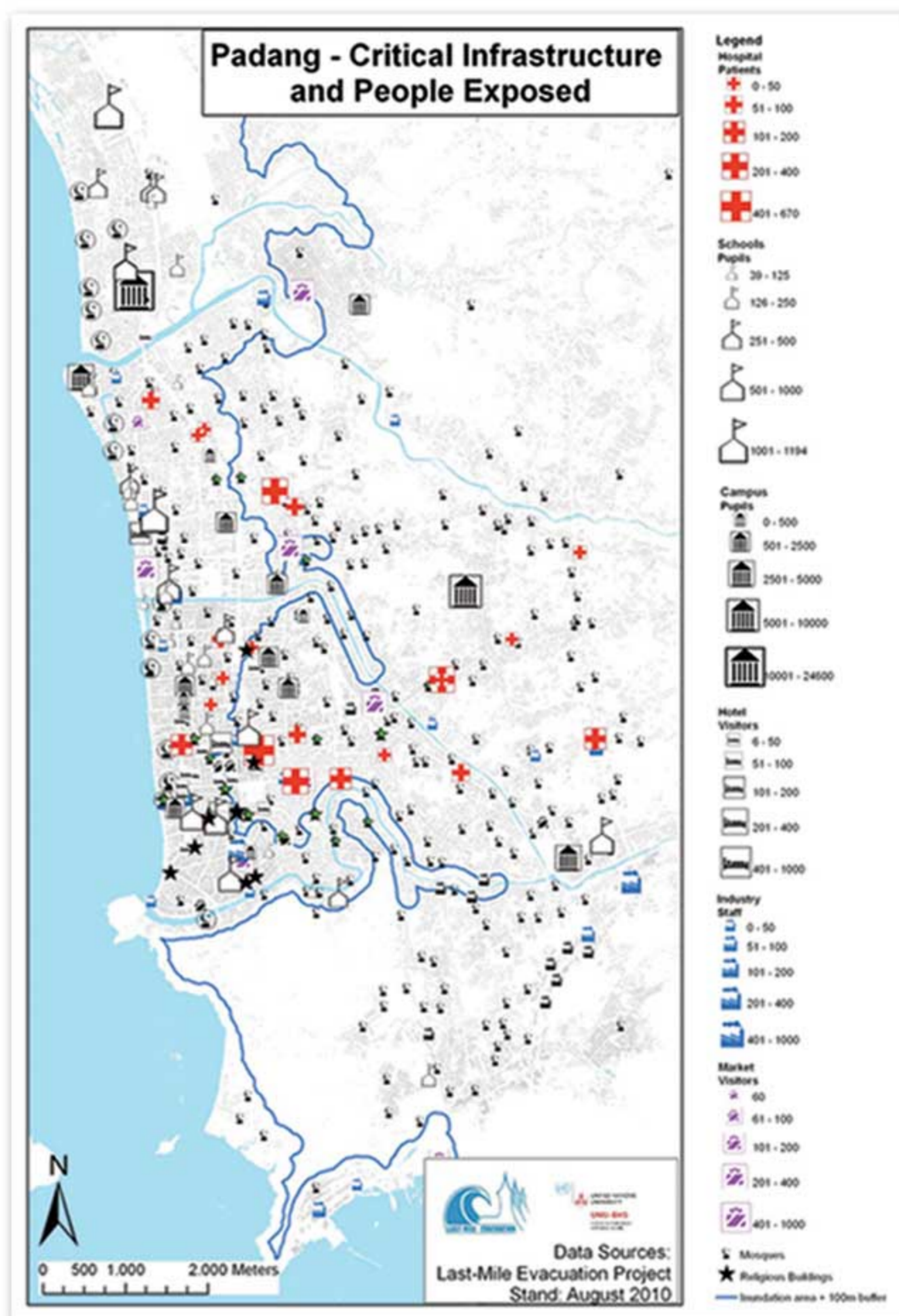
Fishermen, beach vendors and visitors to the beaches are also especially exposed to the threat as they engage in daily activities directly on the coast, and thus, inside the tsunami hazard area.

What infrastructure and facilities can be found inside the tsunami hazard area?

In Step 1, you collected data on several facilities that require special attention during planning and special procedures, evacuation plans and means for warning dissemination during tsunami evacuations. You may now map the location of these facilities and record information in a data inventory. These facilities are:

- schools, kindergartens, universities, training centres,
- hospitals and health centres,
- markets, shopping malls, hotels, tourism and recreation sites,
- mosques, churches, temples and community centres,
- larger government and business offices, detention centres,
- industrial sites, harbours, fishery facilities, railway stations, bus terminals, airports and other facilities where many people gather.

In Step 4, you disseminate your tsunami evacuation plan to these facilities and discuss preparedness measures with the representatives in charge of these infrastructures.

Padang - Critical Infrastructure and People Exposed

Data Sources:
Last-Mile Evacuation Project
Stand: August 2010

This map is an example from Padang, West Sumatra. It shows vulnerable facilities inside the tsunami hazard area (here called "critical facilities"), such as hospitals, schools, hotels, industries, and markets, as well as mosques and other religious facilities. It may give you an idea of how to map the vulnerable facilities in your area (Last Mile Evacuation Project, 2009).

What are the potential evacuation routes?

Now that you are working on the map, you can map main roads in your area that are potential evacuation routes. Evacuation routes lead to areas safe from tsunami inundation. These are all areas inland that tsunami waters cannot reach. However, natural safe areas, such as hills, may also be found closer to the shore. The tsunami hazard map should indicate such locations as areas with no tsunami hazard. At the same time, you may take a closer look at the rivers in your area and map all bridges inside the tsunami hazard area. Bridges can be easily destroyed by the force of tsunami waves and, if possible, should be avoided during evacuations. In Step 3, you will take a closer look at these potential evacuation routes in order to define which ones will be designated as the main evacuation routes.

Where are the areas of high risk?

When mapping potential evacuation routes, you may find that there are areas close to the coast with few or no roads that lead to a safe place. People who are in these areas at the time of an earthquake may have serious difficulties in leaving the hazard zone, because of the limited time for evacuation and the long distance to a safe place. These areas are high-risk areas because they are difficult to evacuate. People in these areas need alternative safe places, such as multi-storey buildings. As a preparation for Step 3, you may start identifying and mapping tall and strong buildings inside the tsunami hazard zone that could serve as evacuation shelter buildings. At this stage, simply identify all buildings that you consider suitable. Step 3 provides references for further analysis of these shelter buildings.
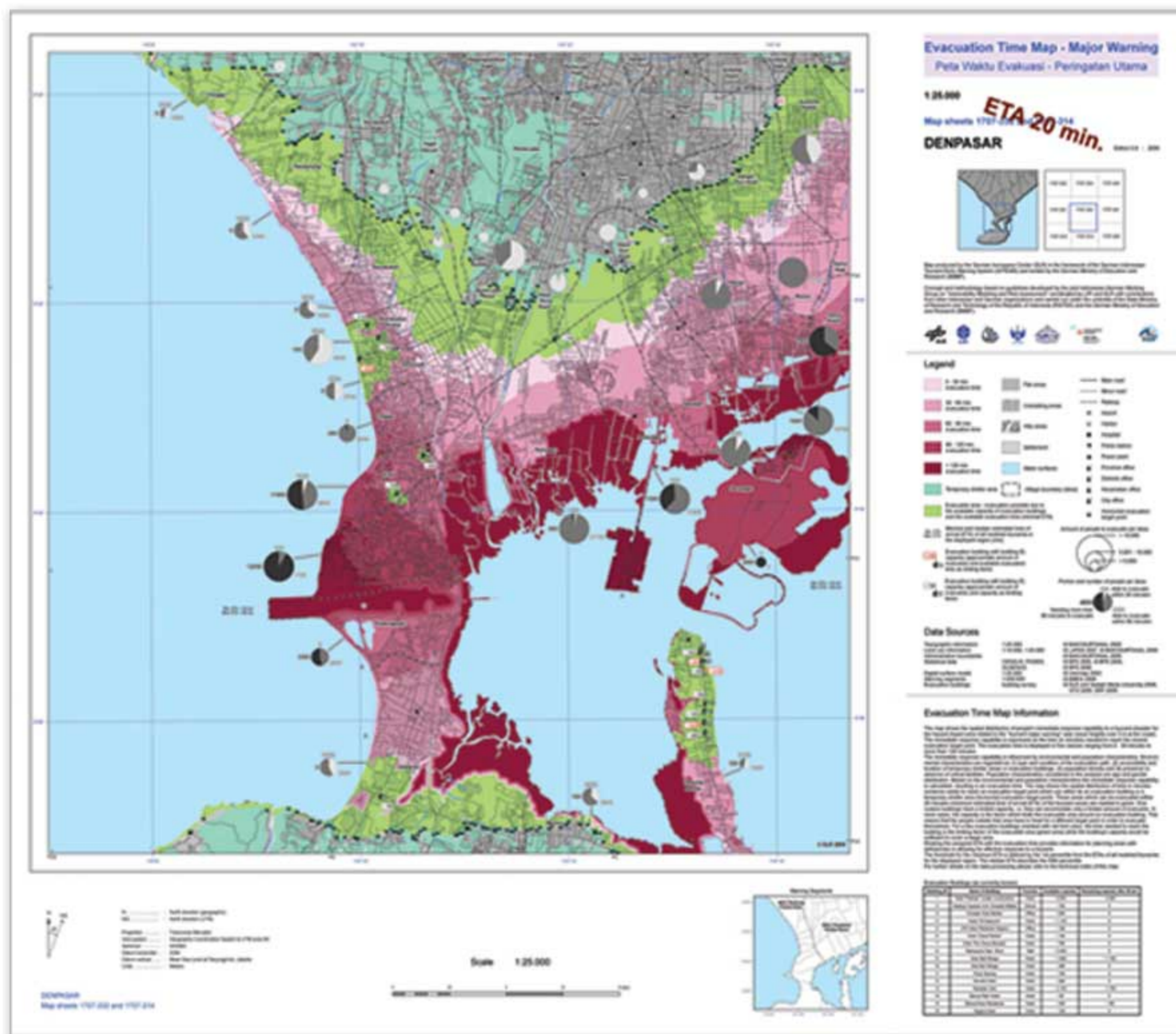
This map is an example of a tsunami evacuation time map from Bali. It shows (in dark red) the areas that will be difficult to evacuate due to the fact that safe areas (further inland) are too far away. Once evacuation shelter buildings are designated, however, evacuation time of the population in their surroundings is reduced. See for example the peninsula Tanjung Benoa in the southeast. Here upper storeys of hotels can be used for vertical evacuation. Thus, the colour green of the peninsular indicates that people have enough time to reach a safe place in the hotels (Evacuation Time Map for Southern Bali, DLR-GITEWS, 2009).

What are your community's landmarks?

You may also start identifying well-known landmarks in your area. These landmarks can be famous monuments, roads, intersections, buildings, or other locations that everybody in your community knows. If posted on the evacuation map, landmarks will help people orientate themselves during evacuations.

Once you have mapped and inventoried all of this information regarding the exposure of population and facilities, potential evacuation routes, potential shelters and landmarks, you have taken a big step forward. This information is the basic material that you need to agree upon the local evacuation strategy and to produce your tsunami evacuation map.

Preparedness and readiness to evacuate

Now we turn to the second aspect that influences your community's vulnerability to the tsunami threat: people's preparedness and readiness to evacuate. You can produce a reasonable tsunami evacuation plan without a detailed assessment of people's preparedness. Understanding the factors that influence this preparedness is especially important for Step 4 of the planning when you design the dissemination and outreach strategy for your evacuation plan and produce information material to raise people's knowledge and awareness. It helps to look at the perspective of the people you are developing the evacuation plan for; that will make you aware of their challenges and needs with regards to tsunami evacuations.

Assessments of the evacuation preparedness of a community yield the best results if they directly involve the people exposed to tsunami hazards. Discussions during community meetings, informal interviews and surveys are ways to get a better understanding of people's vulnerability. Usually social science experts and NGOs conduct these assessments, which can be either highly methodical or simplified appraisals. If data from a tsunami vulnerability assessment is available, examine it and search for information about the points addressed in this section. If there is no such data, you may consider two options to increase your knowledge:

1) There is advice in the textbook on how to conduct a survey about tsunami evacuation preparedness and readiness of your community. Keep in mind that the aim of such a survey should not be to extend the theoretical understanding about people's vulnerability in general, but to produce practical information that can be used to design adequate outreach strategies that help to raise people's awareness and increase preparedness.

Suggestions for designing a survey on tsunami preparedness and evacuation readiness

Tsunami risk awareness and evacuation preparedness will save lives during a tsunami, because during an evacuation your community needs to be ready to evacuate and take the right decisions. Assessing the degree of a community's readiness to evacuate is important because it gives you an idea of the different topics that you need to address when conducting awareness campaigns. When designing a questionnaire, focus on the questions below (adapted from Gebert, 2010):

- Do people know how quickly after an earthquake a tsunami could hit the coast?
- Do people think that they will be directly affected?
- Do people know natural warning signs and how to react to them?
- Do people have access to official tsunami warnings?
- Do people trust official warnings and do they understand their content?
- Do people believe that they can manage to evacuate and find a safe place in time?

When conducting your survey you should follow some important rules:

- Develop criteria for the assessment together with colleagues from government departments, local universities, NGOs, and community representatives
- Make sure that all of the questions above are represented.
- If you have little experience with designing a questionnaire and a survey, you may find advice at your local university and statistics office
- Develop simple questions that people can understand
- Take enough samples so that the different social groups in the community are represented
- Only select samples in the hazard zone, but try to capture households close to the coast, as well those located more inland

The results of a survey can be presented in the form of graphs and maps, which you can discuss with the planning team and with others stakeholders. For further advice on how to conduct an assessment of tsunami preparedness, you may contact the Indonesian Institute of Sciences (LIPI).

2) If you decide not to conduct a survey, you can consult community representatives and members of community organisations and discuss the topic of evacuation preparedness with them. Representatives from local NGOs working in the field of community disaster preparedness may share their knowledge on people's perspectives and attitudes towards the tsunami threat. The points below are based on experiences in other tsunami-prone areas of Indonesia and are equally relevant for your community. Discuss them with your planning team, community

representatives and other resource persons, and find out about the conditions in your area. A simple mind map can help to document your discussion results. You may discuss most of the topics below now or after Step 3 when you already have an evacuation map and overall strategy. However, access to official warnings and guidance (see below) must be addressed immediately, as it is required to define your evacuation strategy in the next step.
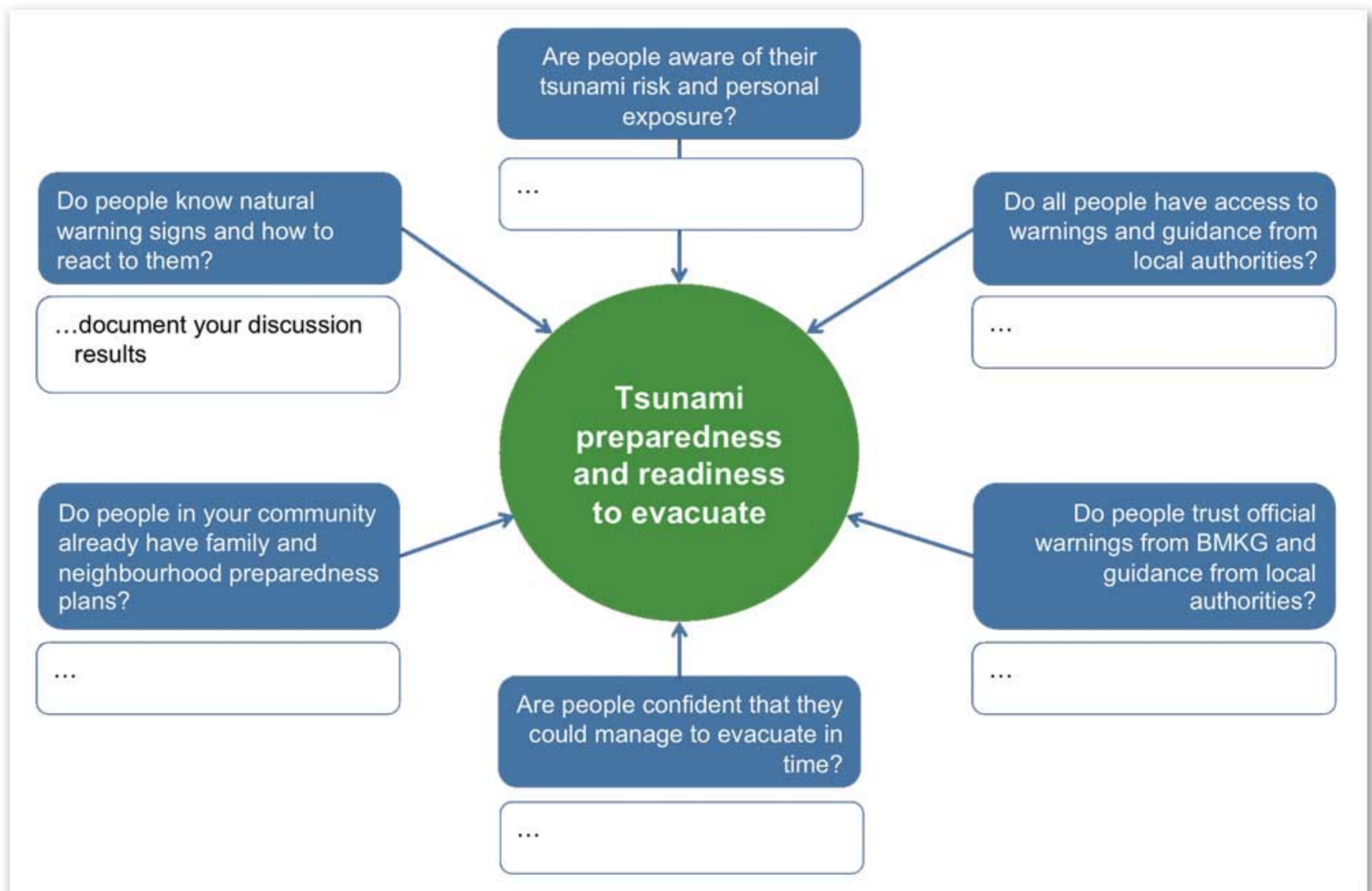
A mind map is a diagram used to organise ideas and knowledge around a central key word or question. Discuss the questions surrounding tsunami preparedness and readiness to evacuate with the planning team and others. This may not answer all your questions, but it is a good start towards a better understanding.

Tsunami risk knowledge and awareness of personal exposure

If people are not familiar with tsunamis or do not perceive them as a threat to their lives why should they care about getting prepared for them? In Aceh and in many places that were hit by tsunamis, people were taken by surprise. Most people were not aware that they live in a tsunami-prone area. They did not know that a strong earthquake under the sea could cause big sea waves that could flood coastal areas shortly after the quake (the exception are the people of Simeulue who describe this natural phenomena as "Smong", which translates

to "the ocean coming onto the land"; McAdoo, et al., 2006). Without a doubt, a community's knowledge about its own tsunami risk is a precondition to preparedness. If there are no studies that inform you about the state of your people's tsunami knowledge and awareness, talk to people to understand their perspectives. Holding a small community meeting will give you an insight into people's knowledge. Your tsunami evacuation plan helps to strengthen this awareness. Step 4 explains what you can do to raise people's awareness of the tsunami risk and at the same time disseminate and promote your evacuation plan effectively.

People's perception on whether they could manage to evacuate

Due to their belief or perception of their place in society, some people may see tsunami disasters as fate. They may feel helpless in the face of the tsunami threat, which may inhibit their willingness and readiness to evacuate. Experience from Padang suggests that some people who do not own a vehicle, like a motorbike or a car, tend to think that they will not be able to evacuate in time anyway although in Padang, evacuation on foot is actually recommended.

Knowledge of natural tsunami warnings and how to react to them

Experience with the earthquake on 30 September 2009 in Padang, West Sumatra, a high-risk area for tsunamis, shows that a considerable number of people may not evacuate immediately after strong ground shaking (Hoppe and Mahardiko, 2010). Often, they first want to be certain that a tsunami will really occur. As many people remember from the Aceh Tsunami that a sudden retreat of the seawater is a sure sign of a tsunami, many people decided to go to the beach after the earthquake to check whether the water was receding, unaware that by doing this they put their life in danger. To address this inappropriate and dangerous response, it is important to make people aware that there are only a few minutes between the moment the seawater starts retreating and the arrival of the first tsunami wave. They also need to understand that the seawater does not always retreat before a tsunami strikes and that waiting for it will put them in extreme danger. They will not be able to escape the deadly waves especially in densely populated coastal plains that do not have higher ground that is reachable in due time. On the other hand, everyone should know that retreating seawater is one of the signs that a tsunami will strike imminently and they need to escape immediately. This is especially important if people did not feel the earthquake or did not receive any official warnings regarding an impending tsunami.

Access to official warnings and guidance

People are more likely to respond appropriately to a warning and guidance message if they receive it in time, understand its contents and urgency, know that it concerns them personally, and believe the information is credible. Even if this is the case, people often still want to confirm that the warning is true and that others are also taking action.

Your community may access tsunami warnings via two main channels: (1) TV and radio stations that forward tsunami warnings from BMKG, and (2) local authorities who are in charge of disseminating warnings to communities in their area and provide guidance on what to do (see reference in Chapter 4 on the Guideline for the Tsunami Early Warning Service of InaTEWS, BMKG, 2010). In Step 1, you were asked to collect information on the tsunami early warning arrangements by the authorities in your area. Discuss this information by going through the following questions:

■ Which institution has the mandate for tsunami early warning in your area?

Tsunami early warning must be quick. It requires clear procedures and agreements on who does what, when and how. A local institution in charge of early warning must be able to receive information from BMKG, make a decision on how the community should respond, and disseminate warning and guidance to all people at risk. There is no time for lengthy discussions on what to do. Only timely warning and clear guidance will save lives. You need to find out who has the mandate to call for evacuation and whether quick procedures are in place and agreed upon. This includes standard messages for warning and guidance. Ideally, the institution that is capable of receiving information from BMKG and spreading it widely is mandated to decide on and disseminate warnings and guidance.

■ Can people be warned at any time?

Earthquakes and tsunamis can happen at any time. BMKG, as well as the local institution in charge of tsunami early warning, must be operational 24 hours a day, 7 days a week (24/7). According to Law No. 24, the Local Disaster Management Agency (BPBD) is in charge of early warning and can use its Operations Control Centre (*Pusdalops*), a technical unit of BPBD, to process and provide early warnings. In areas where a BPBD has not been installed yet this task is often taken over by Kesbanglinmas, the secretariat of Satlak (an ad-hoc emergency response body consisting of all relevant local government institutions). 24/7 operations could also be delegated to the police, the military, the fire department, or other emergency responders.

■ Can all people in your area access tsunami warning and guidance messages?

No matter where they live and who they are, all people in your community need access to tsunami warnings and official guidance. This requires an effective local warning system that reaches all people in a very short time. Tsunami sirens, loudspeakers (e.g., at mosques) and local radio stations can disseminate warnings and guidance quickly and directly to the public. VHF radio communication networks can spread information as well, though only to a limited number of recipients. Telephone communication or SMS are not very reliable means of warning dissemination as they often break down or jam after a strong earthquake. Traditional notification devices, such as wooden drums, may be a good solution when people who operate them have access to warnings and guidance. You need to find out which areas are already covered by warning dissemination devices and which areas need to have better access to public notification. Areas that cannot be reached with warnings and guidance are also considered areas of high risk (see Chapter 4 for reference to the Guidebook on Local Tsunami Warning Dissemination in Indonesia, GTZ IS-GITEWS, 2010).

■ Do people understand warning and guidance messages?

Different people and communities use different languages—or use language differently. The content of warning and guidance messages must be tailored to the needs of all communities in an area, taking into account their cultural, social and educational backgrounds. In areas with many international visitors, announcements in English must be considered. People must know what the content of a warning and guidance message means. The three-minute steady sound of a tsunami siren in Indonesia, for instance, is the sign for immediate evacuation. Sirens, loudspeakers, local radio stations, as well as radio communication networks can be used to make announcements. People are more likely to react appropriately if this guidance states in a clear, specific and consistent manner:

- The official warning source, i.e., BMKG and the local institution/authority;
- The source of the threat, i.e., the earthquake and the tsunami threat;
- The area that might be affected by the tsunami;
- The urgency of the response; and most importantly
- Clear instructions on what people must do.

Guidance messages should also call upon people to stay calm and to not panic. Telling people when and how to get additional or follow-up information is important as well.

■ Do people trust and respect tsunami warning and guidance messages?

It is important not only what is communicated, but also who communicates it. People are more likely to respond to messages from formal or informal community representatives who are considered trustworthy and credible. False alarms may reduce people's trust in the warning system. As early warning for local tsunamis involves much uncertainty, it is important to explain that even though the first warning from BMKG—as it usually will be based only on earthquake data—does not provide 100% certainty about whether tsunami waves are on their way, immediate evacuation is required, as the short arrival times of a locally generated tsunami will not allow people to wait for final confirmation. Communities are more likely to keep their trust in the warning system if they understand this uncertainty.

Being prepared and ready to evacuate in time

The ultimate goal of your tsunami evacuation planning is to inform your community about evacuation routes that will bring them to a safe place in time. However, as experience shows many people do not evacuate immediately after a strong earthquake or official warning. Some may collect valuables from their homes before they leave. Many people want to make sure that their relatives, especially their children and spouses, as well as their friends receive the warning and evacuate as well. Looking for relatives and friends, and probably entering the hazard zone instead of moving immediately away to a safe place reduces their evacuation time. That is why individual, family and neighbourhood response plans are very important. Evacuation plans in schools make sure that children are evacuated by the teachers and can meet their parents in an agreed-upon location in the safe area.

Output of Step 2: maps, data inventory, mind map and assessment report

You have now established a good understanding of your community's tsunami risk. Make sure that you map all the above information and/or include it into a simple data inventory. If you conduct a survey on your people's preparedness to evacuate, the assessment report is another output of Step 2. Results are usually presented in the form of maps, graphs and tables. If you decide to simply discuss the topic with the planning team, representatives of the community and NGOs, you can display your information on a mind map. Now you have the main input at hand, which allows you to develop a tailor-made evacuation map and strategy for your community in Step 3.

STEP 3:
Design your evacuation strategy and map

Now, as all relevant information regarding evacuation planning has been collected, analysed and mapped in Step 2, a discussion about the overall evacuation strategy is the next step on the way towards the tsunami evacuation plan. The main aspects that define your evacuation strategy are the evacuation zone, the modes of evacuation and a clear agreement on when to evacuate. Use the map that you produced in Step 2 that already includes the hazard zone, potential evacuation routes and areas of high risk and develop it further.

Define the tsunami evacuation strategy by discussing the points below:

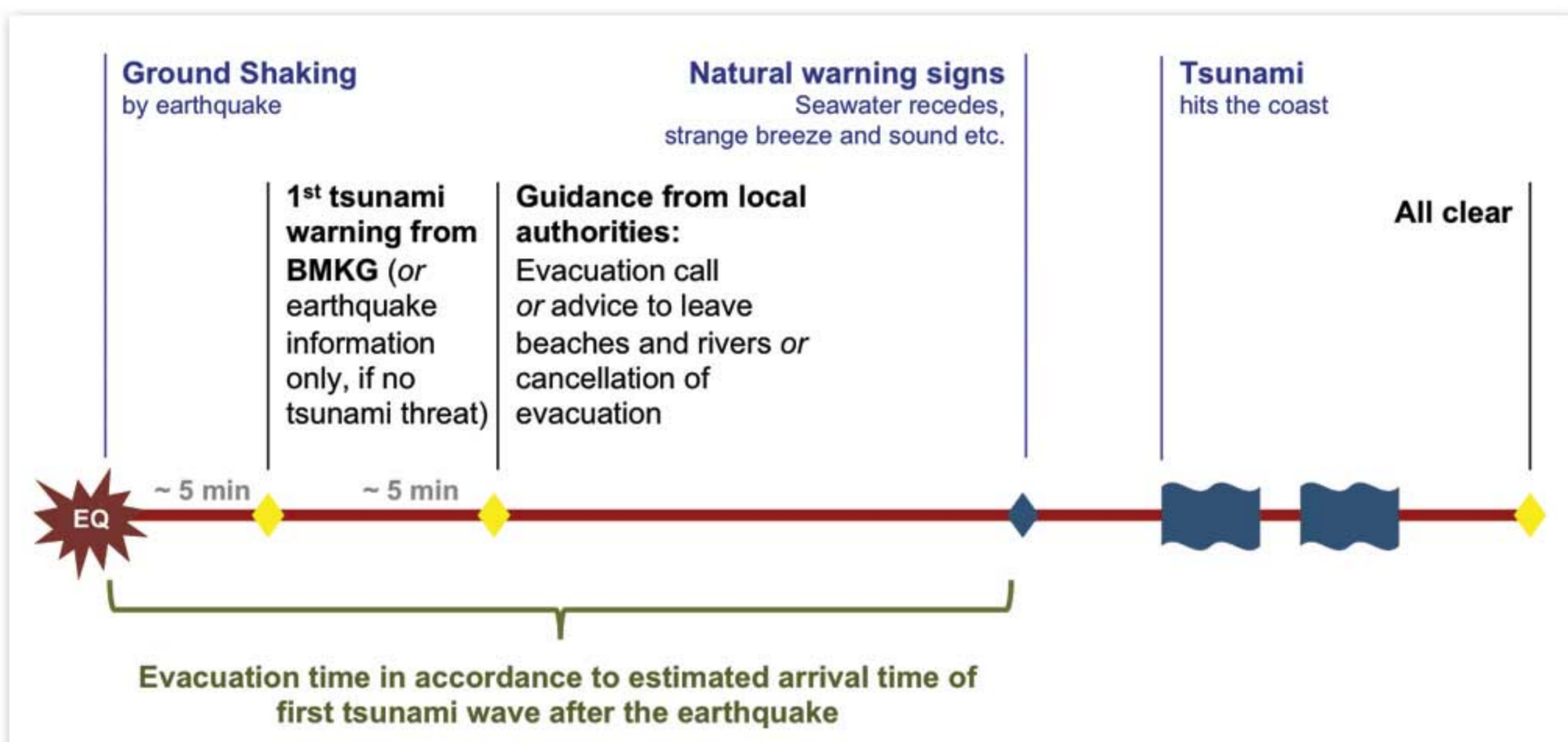| ■ **Evacuation time:**	the time that people have to reach a safe location
■ **Evacuation zone(s) and safe areas:**	the zone(s) that people need to leave and the areas that are safe from tsunami inundation
■ **Modes of evacuation:**	horizontal and vertical evacuation, evacuation on foot, by motorbike or car
■ **Evacuation routes:**	the paths that lead to safe locations
■ **When to (self-)evacuate:**	the trigger for evacuation

You may then continue with the discussion of supporting measures for evacuation:

- ■ Traffic management
- ■ Support for vulnerable facilities during evacuations
- ■ Evacuation signage

The output of Step 3 is a preliminary tsunami evacuation plan that includes the evacuation map and strategy, supporting measures for evacuation and recommendations on further steps that need to be taken (see proposed outline for a tsunami evacuation plan document at the end of Step 3). You may start drafting it as you proceed with the discussion and review it with the planning team. You also need to produce an evacuation map for public use, including simple procedures for evacuation. In Step 4, you can gather feedback from community representatives on this map's and your plan's usefulness.

Evacuation time

Any evacuation strategy depends on the available evacuation time. In the case of tsunamis, this is the period between an earthquake and/or official warnings from a warning centre, and the moment a tsunami floods a coastal area. As tsunami source areas are located close to the Indonesian coast and tsunamis travel fast, evacuation times are generally very short. The estimated tsunami arrival time after an earthquake (see Step 2) gives you the evacuation time for your community. This is the time available to your community to reach a safe place during tsunami evacuations. You may find it helpful to draw a time line that shows the trigger for evacuation (e.g., the earthquake and official warning as well as guidance) and the evacuation time.

Ground Shaking
by earthquake

Natural warning signs
Seawater recedes,
strange breeze and sound etc.

Tsunami
hits the coast

1st tsunami warning from BMKG (*or* earthquake information only, if no tsunami threat)

Guidance from local authorities: Evacuation call *or* advice to leave beaches and rivers *or* cancellation of evacuation

All clear

EQ   ~ 5 min   ~ 5 min

Evacuation time in accordance to estimated arrival time of first tsunami wave after the earthquake

Warning and evacuation time line

Evacuation zone(s) and safe areas

The evacuation zone is the area that needs to be evacuated before and during a tsunami. The most important reference for defining the evacuation zone is the tsunami hazard map. The hazard map shows you the areas that could be flooded by a tsunami, as well as safe areas that are out of reach of tsunami inundation. Safe areas are areas further inland and on higher ground close to the coast.

You may now delineate the evacuation zone by referring to the line of maximum tsunami inundation as indicated in your hazard map. When doing this, it is recommended to draw the boundary along well-known roads or other landmarks, making sure that all tsunami hazard areas are inside the evacuation zone. These landmarks will help you to explain the evacuation zone to the public and provide orientation to the people during evacuations, as some people are not familiar with reading maps, but will remember certain road names or other landmarks that lead to safety.

If your area, or parts of it, is densely populated, it is recommended to add an additional buffer between the line of maximum inundation and the boundary of the evacuation zone. This buffer zone can help to avoid traffic congestions that trap evacuees inside the hazard zone.

In a densely populated area, many people will evacuate simultaneously. This will lead to congestion. Anticipate these congestions by creating a "buffer zone". This buffer zone extends the hazard zone by some hundred meters, which means that your evacuation zone is the result of the tsunami hazard area plus the buffer zone. This additional buffer for evacuation helps to avoid traffic congestions that could trap evacuees inside the tsunami hazard zone as people continue to attempt to move to safe areas further inland. In Padang, the evacuation planning team used a maximum buffer of up to 500 m in some densely populated areas (a very conservative approach, see sketch map from Padang on the left; Last Mile Evacuation Project, 2010). Do not extend the buffer farther than this, as this increases the distance that people must cover to evacuate.
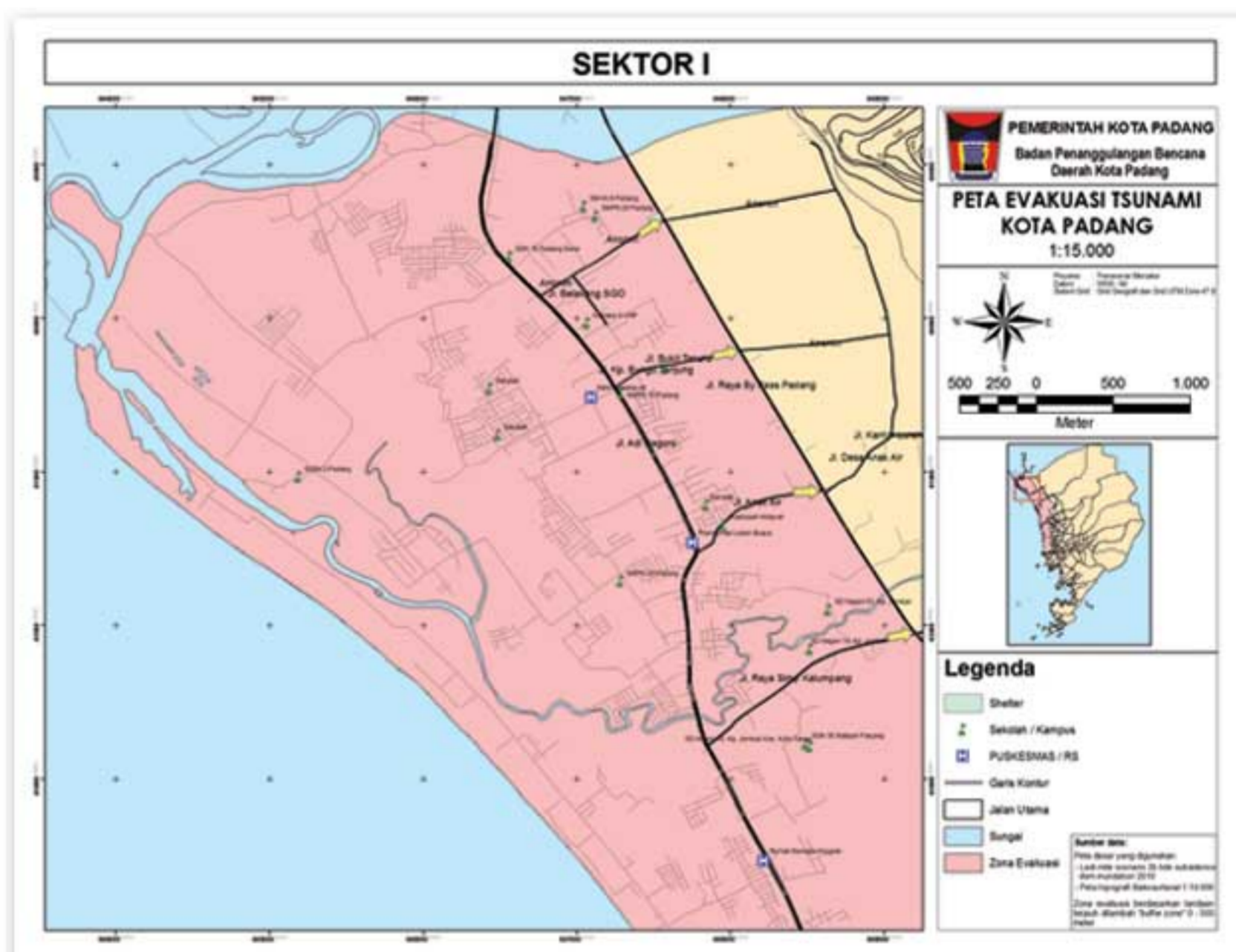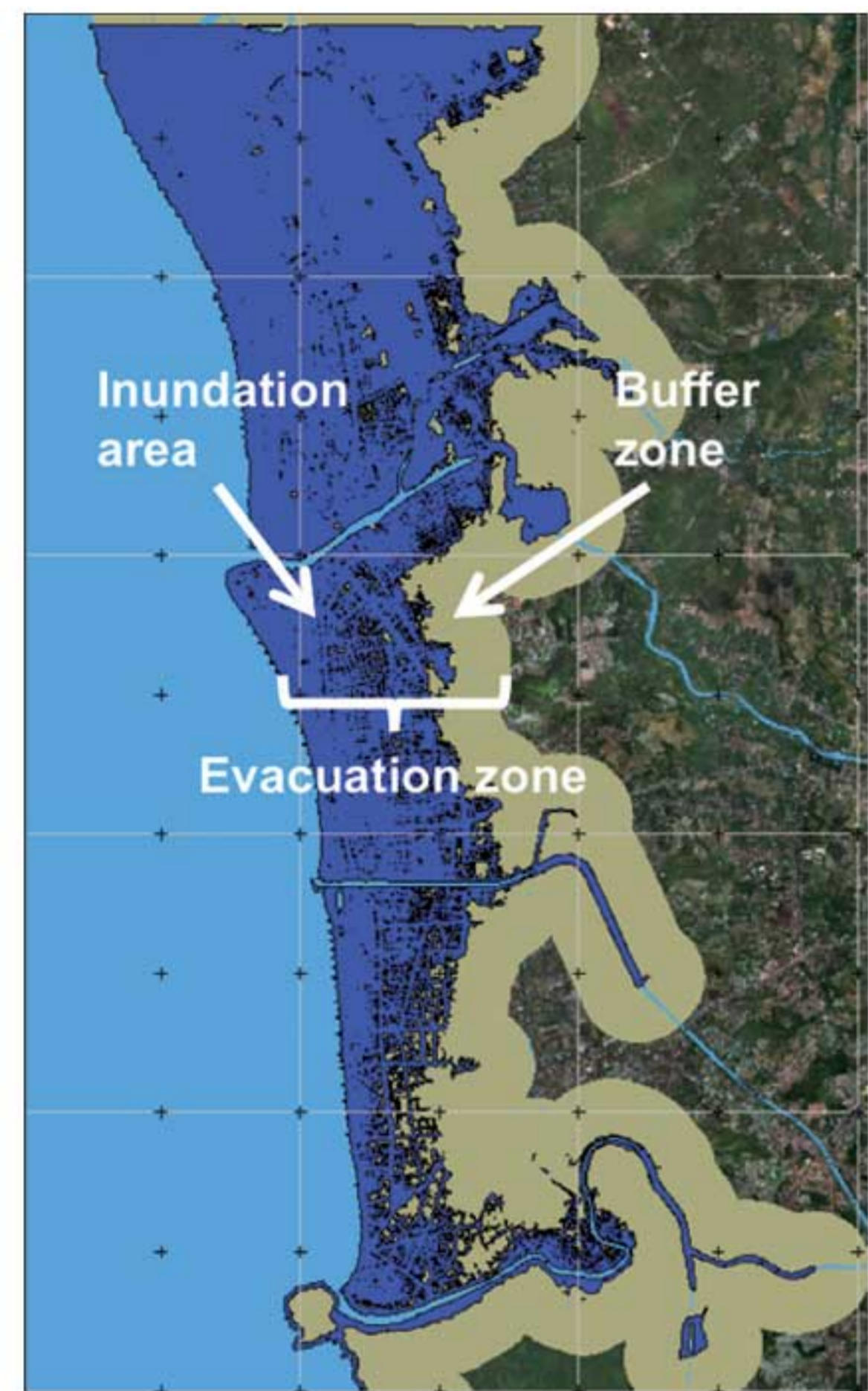
The tsunami evacuation planning process in Padang, West Sumatra, was still ongoing at the time this guidebook was being written. This map shows Sector 1 of the (draft) tsunami evacuation map of the city. The light red colour indicates the evacuation zone. The evacuation zone is the result of the hazard area and a buffer zone (Tsunami Evacuation Map of Padang, BPBD Padang, draft September 2010).

While the tsunami evacuation planning team in Padang decided to establish only one evacuation zone for the sake of simplicity in planning and public communication, some areas use two evacuation zones instead of only one.

Two evacuation zones instead of one

In low-lying coastal areas, hazard and evacuation zones may extend inland for several kilometres. This presents evacuation planners with

a dilemma, as people will have severe difficulties in leaving the evacuation zone in time, especially if there are few direct roads that lead to safety and/or high population density is likely to cause traffic congestion. Under such circumstances, evacuating vertically to multi-storey buildings and official evacuation shelter buildings is often the only solution for people in areas that are difficult to evacuate to reach a safe place (the section, *modes of evacuation*, below explains in greater detail vertical evacuation in areas of high risk).

Applying a concept of two evacuation zones can be an additional way to handle evacuation of large evacuation areas. It allows distinguishing between zones of higher and lower risk. Thereby you can set priorities and define different actions that need to be taken in these zones during a tsunami emergency. The establishment of two, instead of one, evacuation zone is based on two main assumptions:

1) Areas close to the coast will suffer the strong and destructive physical impact of the waves (Impact Zone), whereas areas further inland will "only" be flooded (Inundation Zone). Several post-tsunami studies show that there is strong correlation between the death rate and the distance from the coast. Therefore, it is important to concentrate evacuation efforts on areas close to the coast. Matching one evacuation zone with the Impact Zone places an emphasis on this matter.
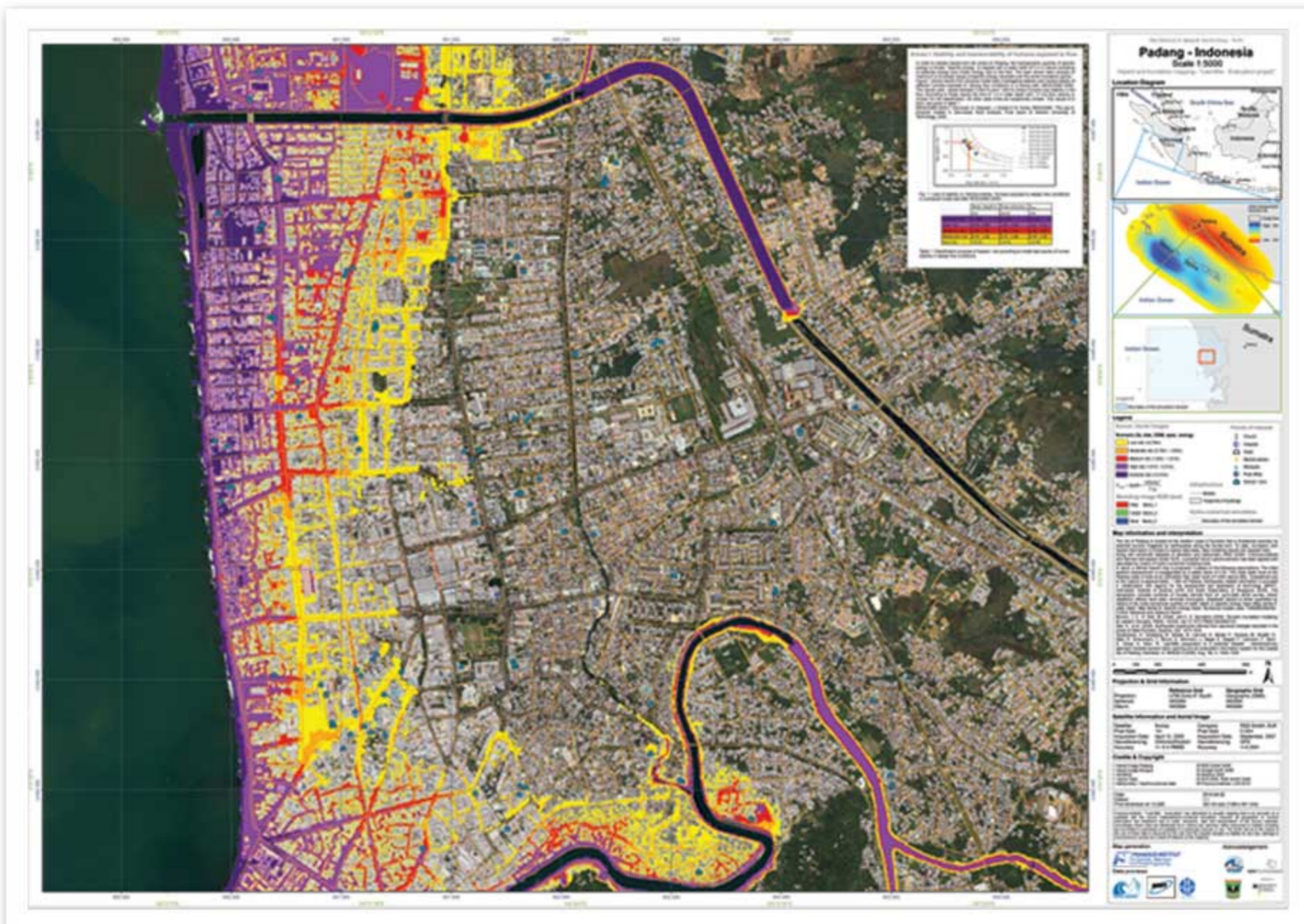
Some tsunami hazard maps show the impact zone of tsunami waves and the areas where depth and energy of tsunami waters is high, like this example from Padang (here in purple and red; Last Mile Evacuation Project, 2010). If your hazard maps provide you with such detailed information, you can use it to define different evacuation zones and procedures.
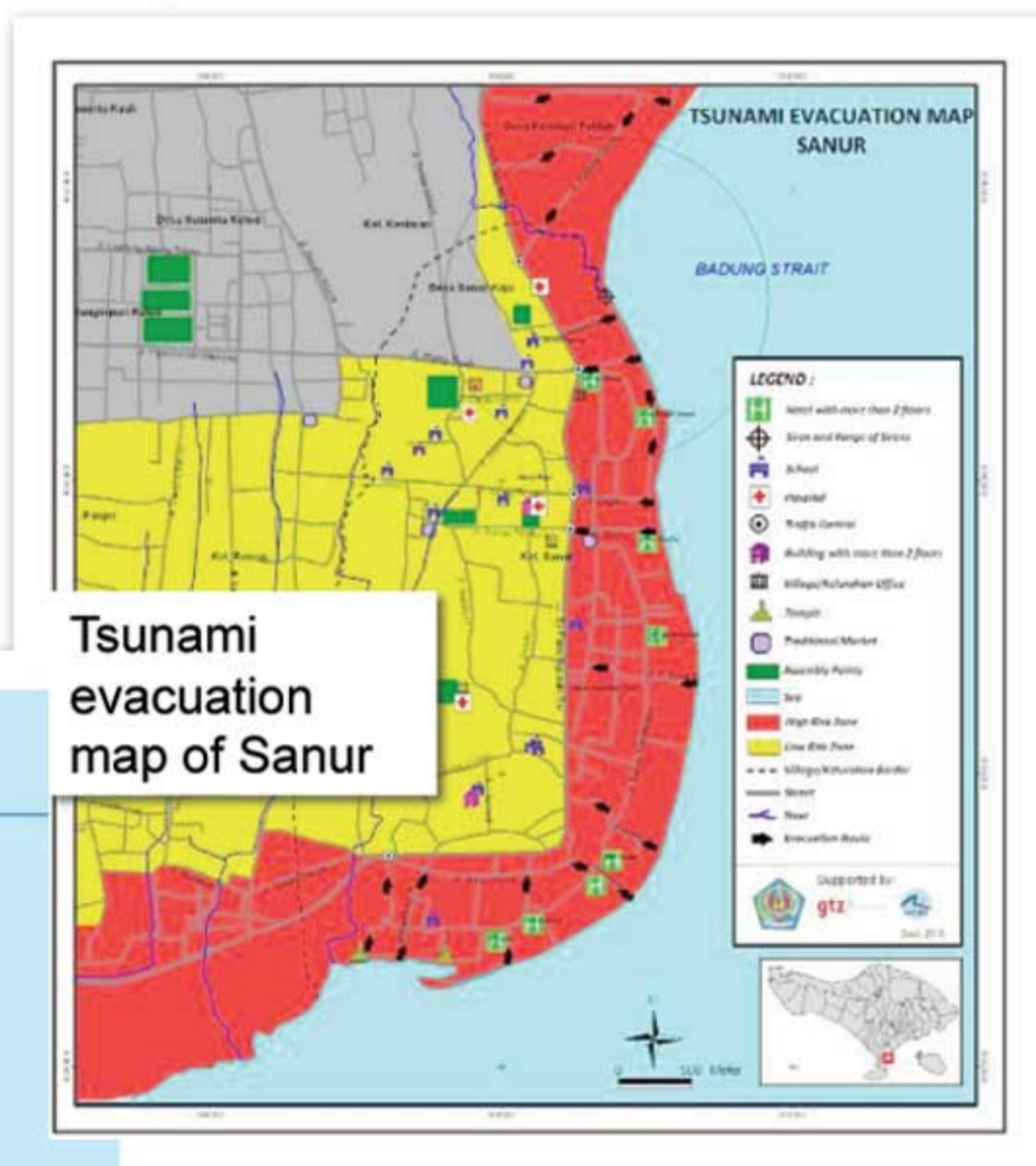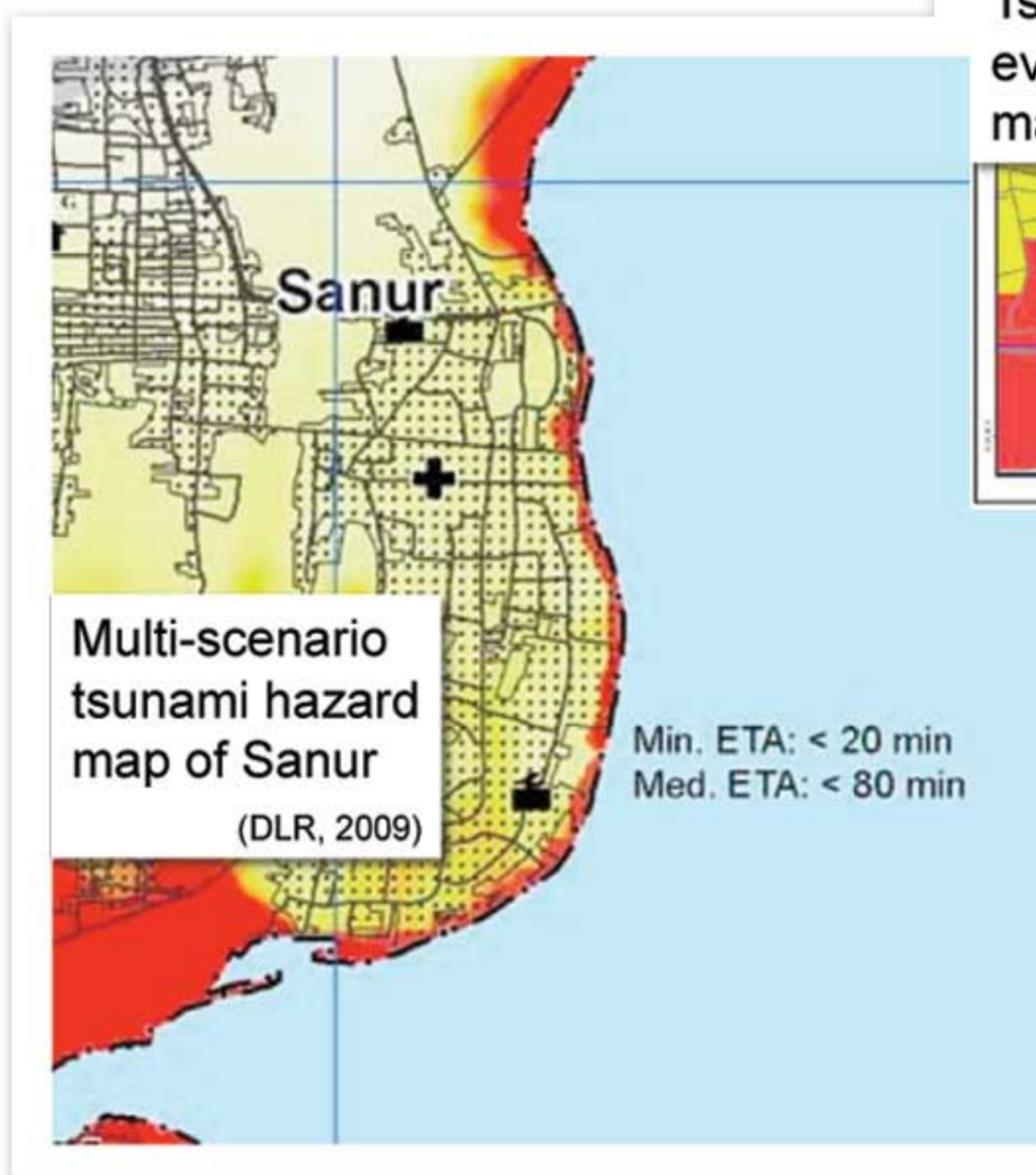
2) The probability of a tsunami with a certain magnitude varies considerably. Historical experience and statistics show that Indonesia suffers from a destructive tsunami every two to three years (Hamzah Latief, et al., 2000). Post tsunami surveys indicate that the maximum inundation areas of these kinds of "average" tsunamis barely exceed 500 m. The probability of a worst-case scenario with an inundation area of up to four km, such as during the tsunami in Aceh in 2004, is considered relatively low. Evacuation zones can distinguish between the inundation areas of "average" and "low probability" tsunamis. This consideration is especially relevant if you use a tsunami hazard map that employs multiple tsunami scenarios.
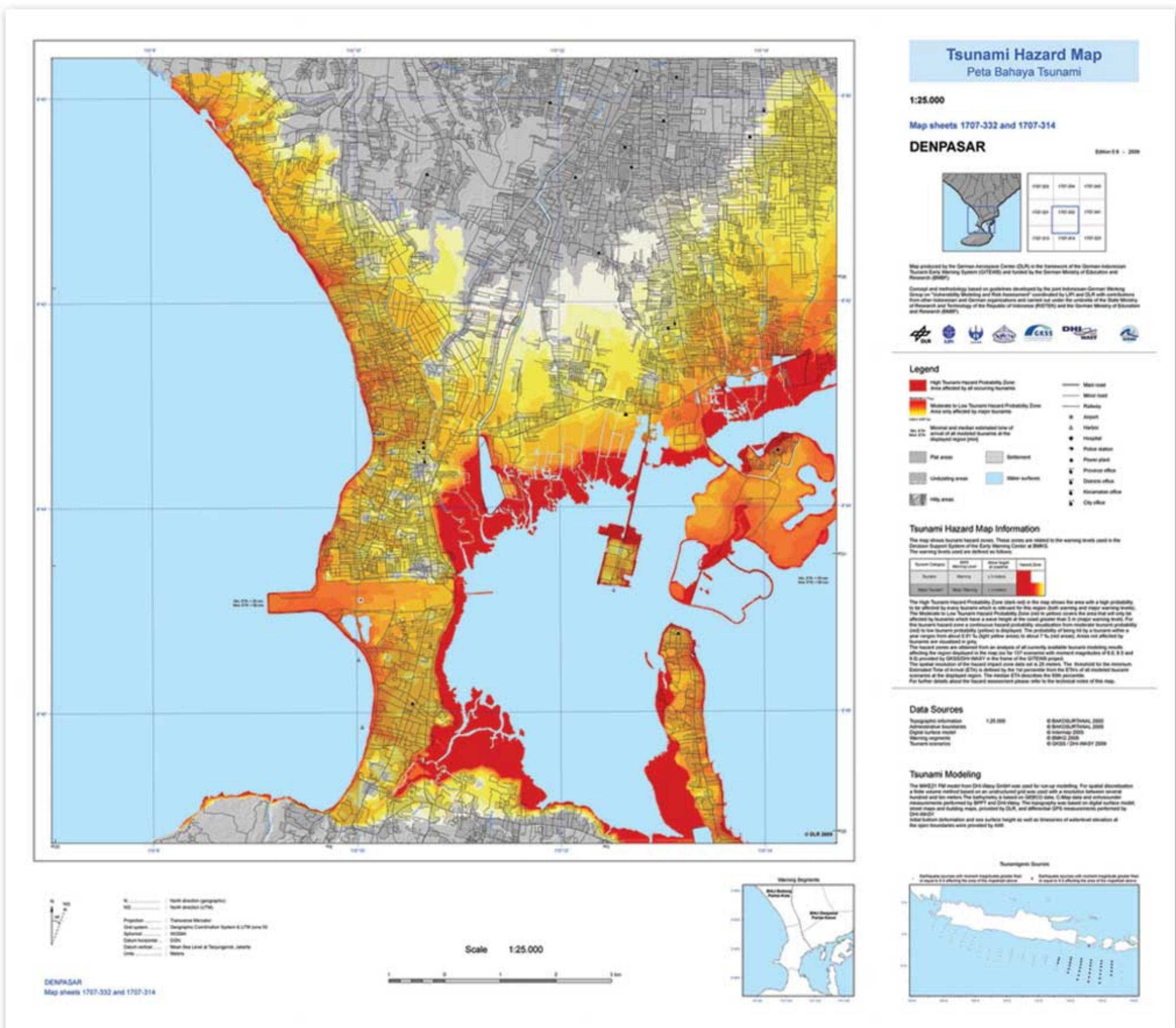
This tsunami hazard map of Bali shows areas with high (in red) and low (in yellow) probability of being hit by a tsunami, depending on how many of the calculated scenarios flood a specific area on the map (Official Tsunami Hazard Map of Bali, developed by DLR as part of the GITEWS Project, 2009). If your hazard maps provide you with such information, you can use it to define different evacuation zones.

In Kelurahan Kuta and Sanur, Bali, the evacuation planning team decided to establish two evacuation zones. To distinguish two zones, they used the information on the probability of tsunami inundation in the multi-scenario hazard map. Their consideration was that due to the limited evacuation time, it would not be possible to evacuate the entire inundation zone. The two evacuation zones indicate different procedures in dealing with this challenge:

- People who are in the red zone need to either leave the red zone and evacuate to the yellow zone or evacuate to upper floors of buildings and evacuation shelter buildings within the red zone, where available.

- People who are in the yellow zone do not need to leave the yellow zone, but should evacuate vertically to upper floors of buildings, as safe areas are too far inland. People who evacuate from the red zone into the yellow zone are also asked to evacuate vertically.

Tsunami evacuation map of Sanur

Multi-scenario tsunami hazard map of Sanur

(DLR, 2009)

Min. ETA: < 20 min
Med. ETA: < 80 min

Evacuation zones in Sanur, Bali, distinguish between areas of higher and lower probability of tsunami inundation (see tsunami hazard map on the left). In the evacuation map, these zones are called: high-risk zone, in red, and low-risk zone, in yellow (see evacuation map on the right). The high-risk zone also covers the area close to the coast, which is expected to suffer impact of the direct force of the tsunami waves. The grey zone is the safe area. During field visits, the evacuation planning team found that areas in the northern part of Sanur have higher elevation. These areas are now considered to be safe areas (Official Tsunami Evacuation Map of Sanur, Bali, 2010).

In any case, to keep the evacuation strategy simple and to avoid public misunderstanding, it is not recommended to establish more than two evacuation zones. Whether to establish one or two evacuation zones is a decision that needs be made with the planning team. Decide on the best way to explain the evacuation strategy and procedures to your community and to urge people to react appropriately. You may consider two evacuation zones if:

- Your area is low-lying and densely populated, and people are unlikely to reach safe areas in time;

- You want to indicate a zone that should be prioritised during evacuation due to higher risk, i.e., direct wave impact or high probability of tsunami inundation;

- You want to outline a high-risk zone that should be completely evacuated, whereas people in areas further inland will not necessarily have to leave the low-risk zone, but should evacuate to relatively safe places inside the evacuation zone (as currently discussed in the rural district of Purworejo, Java);

- You think that indicating two zones helps your people to better understand the evacuation strategy.

Linking evacuation zones to the warning levels of InaTEWS?

Beginning in 2011, BMKG will switch to a warning scheme that indicates different warning (or threat) levels. These warning levels are based on estimated tsunami wave height at the coast. The warning messages will also include an advice by BMKG on the expected response along the coast:

Warning level	Estimated wave height	Advice
Advisory	up to 0,5 m	Move away from beaches/rivers
Warning	between 0,5 - 3 m	Evacuation
Major Warning	higher than 3 m	Full-scale evacuation

Ideally, it would make sense to link evacuation zones to the two warning levels (warning and major warning). This would allow for evacuation of specific zones depending on the warning level. This would avoid "over-evacuation" when the forecasted tsunami threat is minor, as indicated by the warning level "warning". Evacuation of the zone in line with this warning level would be sufficient.

However, the current threshold for the warning levels "warning" and "major warning" are not in line with evacuation zones, which distinguish between "average" and "worst case" tsunamis:

The red zone in the GITEWS multi-scenario hazard map (left) indicates the calculated inundation area by a tsunami < 3 m (representing the InaTEWS warning level "warning"). It is clearly visible that this zone is confined to a very narrow coastal strip, whereas the red zone in the evacuation map of Kuta (right) stretches much further inland as it covers the inundation area of an "average" tsunami in Indonesia (up to 500 m inundation).

In conclusion, this means that the current warning levels do not coincide with the logic of local evacuation strategies and are hardly applicable to call for differentiated action (evacuation of only the red or both the red and yellow zones).

Another important question is whether a strategy, which distinguishes between partial (only red zone) and full-scale evacuation according to the InaTEWS warning levels is a realistic option when it comes to implementation. Considering the current state of public understanding of the warning system and the difficulties in disseminating warnings and guidance locally, the option of such a two-level approach still seems questionable. An evacuation concept distinguishing between partial and full-scale evacuation only makes sense if there are means to clearly communicate the two warning levels to the people at risk in an emergency situation. Even if suitable dissemination technology were available, it would not necessarily mean that people would remember the different meanings of siren sounds or announcements in the long run and be able to react accordingly.

It is currently not recommended to link your evacuation zoning to the warning levels of InaTEWS.

Modes of evacuation: horizontal and vertical evacuation

Evacuation can be horizontal, i.e., towards safe areas further inland, or vertical when people move above tsunami waters to upper floors of buildings or official evacuation shelter buildings within the hazard zone. Often a combination of both modes of evacuation is used. Whenever horizontal evacuation is feasible it should be the first choice. This depends on the available evacuation time, the distance to safe areas and whether evacuation routes allow for removal of all affected people out of the evacuation zone.

Horizontal evacuation

With regards to horizontal evacuation, you need to decide whether people should evacuate on foot or use motorbikes and cars. In densely populated areas with narrow streets, evacuation should be done exclusively on foot. You need to discourage people from using vehicles as this quickly leads to congestion of evacuation routes. In rural areas, the use of motorbikes (and perhaps cars) can be feasible, especially when the roads that lead inland are few and a safe area is far away. The possibility of traffic congestion in areas with lower population density is minor. If you decide to assign locations where people should gather after they have evacuated from hazard areas, you need to make special arrangements for these assembly areas.

Assembly areas

Specific assembly locations may be identified in safe areas to accommodate and care for the evacuees. These locations may be open fields, e.g., sports fields, stadiums and parks or indoor locations, such as community halls, mosques, churches, and temples (if they are not severely affected by the earthquake). In these assembly locations, emergency responders need to provide services for people's basic needs, i.e., hygiene, food and drinking water, accommodations, health services, and first aid, which cannot be met by the people themselves. The assembly areas should be able to accommodate the expected number of the people in the potentially affected surrounding areas. Planning for assembly areas is part of emergency response and contingency planning, and should be thoroughly prepared. It is not recommended to include assembly areas in your public tsunami evacuation plan if preparations for emergencies have not yet been made.
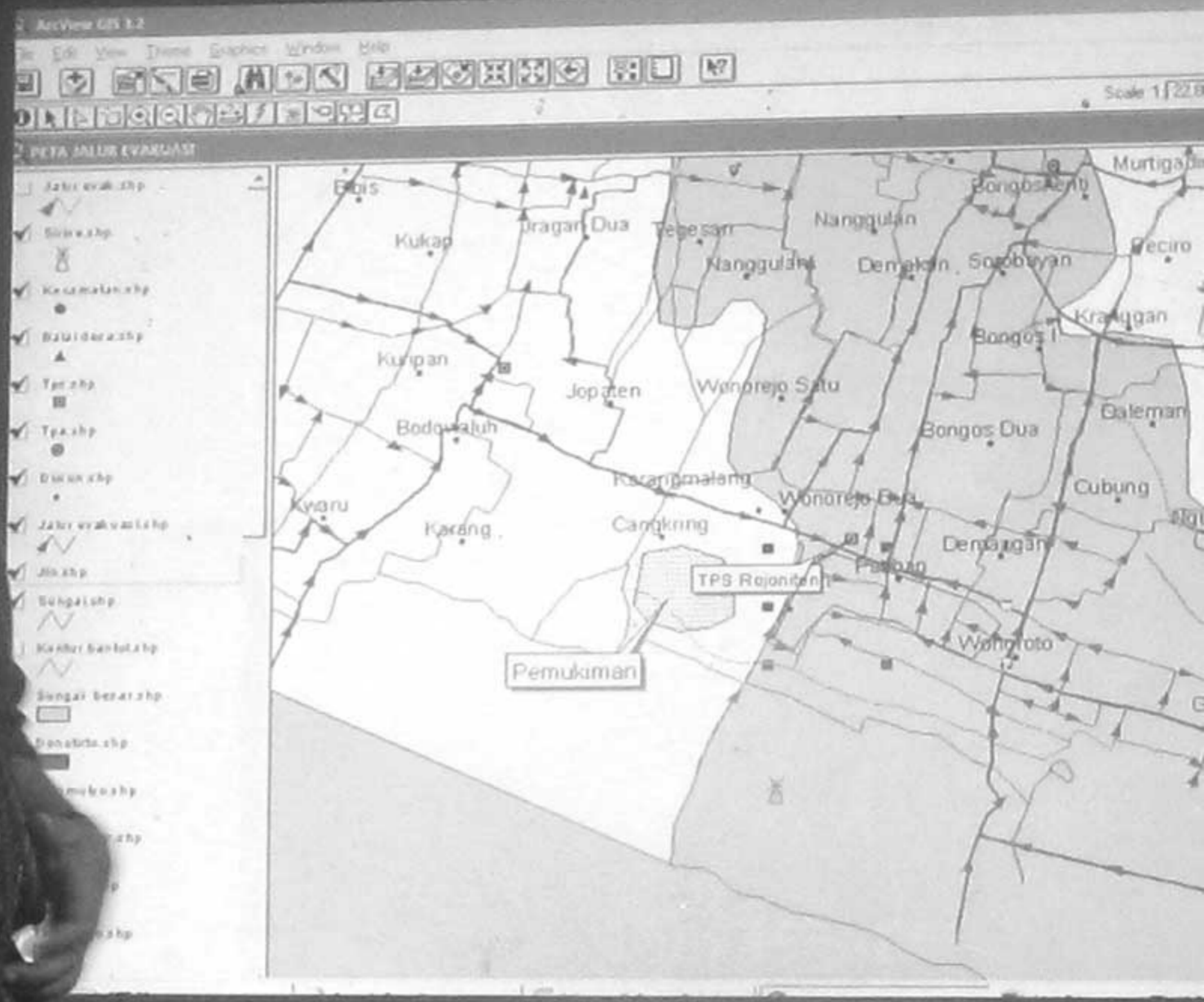
Vertical evacuation

If evacuation time is very short, it cannot be expected that all people will be able to leave the hazard zone before the waves arrive because the safe areas may be too far away. This is the case especially in flat coastal plains where higher ground is far away. People in these high-risk areas that are difficult to evacuate need alternative safe locations. Any location within the hazard zone that is unlikely to be inundated by a tsunami is an option. Safe locations in the hazard zone can be found on upper floors of buildings. This kind of evacuation is called "vertical evacuation". This means that people do not actually leave the area that could be flooded by a tsunami. Instead, they either climb to the upper floors of any building in their surrounding area (wherever possible higher than three storeys), which brings them above tsunami waters, or they move to official evacuation shelter buildings nearby.

Besides the possibility of recommending vertical evacuation to upper storeys of any building as a general mode of evacuation, you might indentify a number of suitable buildings that could function as official and public evacuation shelter buildings.

Evacuation shelter buildings

Take a closer look at the areas of high risk and the tall buildings that you identified in Step 2. These buildings could serve as official evacuation shelter buildings. However, they need to be properly assessed before they can be recommended. It is recommended to involve experts to check whether the buildings identified as potential evacuation shelter buildings for vertical evacuation fulfil certain quality criteria. You should also involve expert knowledge to assure a good understanding about how designated public evacuation shelter buildings will influence the movements of evacuees in order to prevent congestions due to a massive flow of people to selected buildings.

Evaluation criteria for evacuation shelter buildings

Buildings that can be used for vertical evacuation must fulfil certain criteria to withstand the power of earthquakes and tsunamis. It is highly recommended to involve structural engineers in the assessment of shelter buildings. Based on expert knowledge, the criteria can be divided into four main components (order chosen is in line with the importance of each component). An evacuation shelter building must reach a certain security threshold based on all four components:

- An assessment of the structural stability analyses all materials and elements of a building that contribute to its structural stability at large

- Tsunami components describe the general building susceptibility to tsunami waves based on the existing contact surface (e.g., building geometry)

- Accessibility components valuate a building regarding the possibility of accommodating evacuees (see below)

- Liquefaction component: earthquake shaking reduces the strength and stiffness of soil. This phenomenon is called liquefaction. Hence, liquefaction components in the assessment of evacuation shelter buildings are related to the underground soil of a building and its susceptibility to earthquakes.

Vertical evacuation plays an important role in tsunami evacuation planning. Especially in urban areas where population density is high, evacuation shelter buildings are often the only possibility to evacuate people within a limited time frame. For vertical evacuation, two constraints are decisive: (1) evacuation time and (2) building capacity. Only when the time needed to reach an evacuation shelter building is shorter than, or equal to, the estimated time of arrival of a tsunami, can the evacuation be successful. However, as buildings can hold only a certain amount of people, it is possible that evacuees would be able to reach an evacuation shelter building in time, but the building may already be full to its capacity. For evacuation planning, it is of great importance to know about each building's capacity and to identify the area and number of people that can be covered by each building. Generally, shelters should not be clustered, but allocated corresponding to the demand in an area of high risk. Doors and stairs must be wide enough to allow easy access for people. One person requires about 1 m^2 of space in a shelter building. After an assessment has been conducted, you need to agree on procedures with building owners to provide access during emergencies. If no, or not enough, suitable buildings are available, the construction of supplementary infrastructure should be considered.

(More information on the assessment of evacuation shelter buildings can be found in an upcoming guideline for tsunami risk assessment in Indonesia, compiled by the Indonesian-German Working Group on Tsunami Risk Assessment, see Chapter 4)

This map from Padang shows buildings inside the tsunami inundation area that have been indentified as potential evacuation shelter buildings. The digits indicate how many people the building can accommodate (Last Mile Evacuation Project, 2010).

How to survive a tsunami?

UNESCO (2009c), on behalf of its Intergovernmental Oceanographic Commission (IOC), collected recent Indonesian experiences with fast-arriving tsunamis in Aceh (2004) and Pangandaran, Java (2006) from people who survived these disasters. An information booklet summarizes public safety lessons on how to survive:

- Abandon belongings
- Stay out of cars
- Beware of rivers and bridges
- Climb a tall building or tree
- Use a floating object as a life raft
- If offshore, go farther out to sea
- Expect more than one wave

The booklet can be obtained from the website of the Jakarta Tsunami Information Centre: www.jtic.org

Evacuation routes

In Step 2, you identified potential evacuation routes. You may now take a closer look at the evacuation routes and check whether these routes are suitable paths to safety.

Evacuation routes are main roads, smaller streets and paths that lead evacuees quickly to safe areas and evacuation shelter buildings. A road designated as main evacuation routes should be wide enough to allow for movement of the people in the surrounding areas. The best evacuation roads lead away perpendicularly from the coast. If the existing road network is not sufficient, you may need to recommend the construction of additional paths and roads that can serve as evacuation routes.

It must be expected that evacuation routes might get damaged or obstructed by the earthquake. Some roads may be especially prone to tsunami inundation and secondary hazards caused by the earthquake. Avoid the following areas when designating evacuation routes:

- Bridges that could already be weakened by the earthquake and are particularly prone to destruction by the tsunami that travels faster in rivers. The force of the tsunami alone may not destroy a bridge, but objects—including boats and debris—can easily do so;

- Areas that are prone to landslides and collapse of tall and weak buildings;

- Roads with power lines located overhead and areas with power stations;

- Industrial sites that could pose a secondary hazard to the evacuees, such as locations of chemical or oil and gas industries;

- Roads that are close to rivers and river mouths.

Make sure that you involve people from your community who are knowledgeable of your area and the local geography. Together with them you can designate and visualise the best evacuation routes in your evacuation map. Field visits to areas in question may help you to get a better understanding of the possibilities. Involve local residents pro-actively to get their perspectives and learn about short cuts that can serve as evacuation routes. You may also walk along evacuation routes to get a feeling for the time it takes to reach the safe area. A general rule says that people can evacuate at a speed of 1m/sec.

When to (self-) evacuate?

Evacuation with respect to local tsunamis is considered primarily a matter of self-evacuation. People need to move away from beaches and riverbanks close to the coast whenever experiencing ground shaking from an earthquake, and search for information. In case of a strong earthquake people need to evacuate immediately to safe areas and designated evacuation shelter buildings.

For coastal communities where tsunamis are estimated to arrive within only a few minutes of an earthquake, e.g., the Mentawai Islands, official warnings from BMKG are not relevant as a "trigger" for evacuation due to the extremely short evacuation time. Information from BMKG can only be used to cancel an evacuation or inform people when the immediate tsunami threat is over.

Besides these natural warning signs, an official tsunami warning from InaTEWS or a call for evacuation from local authorities is a trigger for immediate evacuation.

The decision to officially call for evacuation lies with your local government. They are also in charge of activating local sirens. A steady three-minute siren is an official call for evacuation.

However, it should be clear policy that your community does not have to wait for tsunami warnings or an evacuation call from local authorities in the case of a strong earthquake, as communication lines and dissemination devices might not be working properly due to network overload or damages by the earthquake.

Therefore, it is recommended for any local evacuation strategy to consider official warnings from InaTEWS (that are issued five minutes after the earthquake) and guidance from local authorities principally as a reinforcement for evacuation and a notification for people in case they did not feel an earthquake or do not feel the need to evacuate—and to call off an evacuation in case there is no tsunami threat. People are supposed to return to the hazard zone only if they receive official information that there is no tsunami threat or an "all clear" message that indicates that the immediate threat from tsunami waves is over.

The institution in charge of tsunami early warning in your area (i.e., BPBD if already established) needs to develop warning procedures and response strategies based on natural warnings and information from BMKG. A clear local policy on how to respond to natural, as well as official, warnings and a call for evacuation contributes to consistent community reaction in case of an imminent tsunami threat (see reaction strategy in Chapter 2).

Based on your discussion in Step 2, when you reviewed your local warning arrangements and policies, you should provide recommen-

dations on how to improve the local tsunami notification system. These recommendations can be included in your tsunami evacuation plan document.

Support during evacuation

The most important support that people need after an earthquake is timely and instructive warning and guidance on what to do. Due to the short warning and evacuation time, supporting measures for evacuation will be very limited.

Guidance for evacuation needs to be disseminated through all possible means repeatedly to make sure that as many people as possible get informed. Beach guards, such as the *Balawista* in Bali or SAR, play crucial roles in helping to disseminate guidance and to evacuate people from public beaches.

Other supporting measures should aim to avoid or minimise congestions due to traffic jams. Therefore, traffic control points should be identified and must be agreed upon to assure that traffic towards the hazard area is stopped and redirected, that traffic in one-way streets leading into the hazard zone is converted outward, and that main intersections outside the evacuation zone are managed by traffic control personnel. If assembly areas have been defined, procedures must be agreed upon to assure that evacuees receive first aid and supplies for basic needs, as well as information.

Promoting family and neighbourhood evacuation and response plans can strengthen self-evacuation capacity. Everyone who is able to evacuate on his or her own should evacuate to a safe location immediately. Families should agree on places to meet after a tsunami evacuation. Agreements amongst neighbours can make sure that elderly, sick or handicapped people get assistance during evacuations.

Vulnerable facilities

All facilities that you identified during Step 2 should be informed about the official tsunami evacuation plan and procedures, and be encouraged to develop their own procedures (see Step 4 for details). Hospitals and primary schools are among those most vulnerable, as patients and young children need special guidance and assistance (see Step 4 for a discussion on school evacuation). Transportation arrangements need to be made for patients who will not be able to leave the hazard area on their own. Hospitals in multi-storey buildings may opt for vertical evacuation to upper floors.

The Indonesian Ministry of Tourism developed a manual, "Tsunami Ready Toolkit", on how hotels can prepare for tsunamis that can be downloaded from the internet (see Chapter 4).

Evacuation signage

Tsunami evacuation signage is an integral part of practical tsunami risk management. Signage depicting evacuation zones and routes raises public awareness of the local tsunami risk and provides information on what to do and where to go.

You need to identify suitable and strategic locations for tsunami evacuation signage that indicates the way to a safe area along the main evacuation routes. Additionally, evacuation shelter buildings, which are officially recognised, should be identified clearly by respective signage.

Indonesia has agreed on a national standard for the design of tsunami evacuation signage (see Chapter 4).

Tsunami evacuation signs for evacuation shelter buildings and horizontal evacuation

Your tsunami evacuation plan, including the map, procedures, evacuation zone, and evacuation routes, can be made available to the general public, also via information signboards.
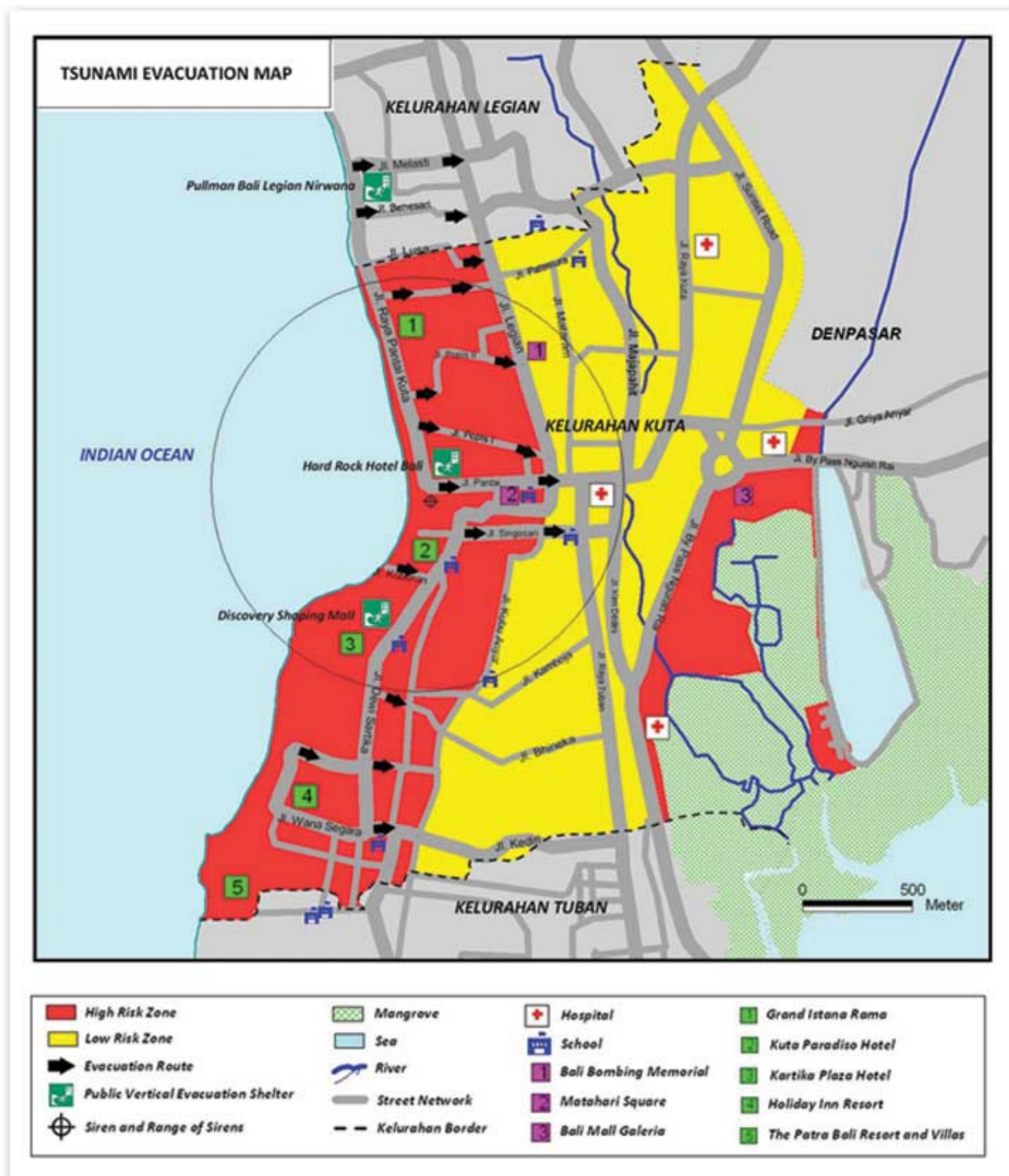
TPS
SD KORIPAN
3.2 KM

You have now designed your preliminary tsunami evacuation plan. Make sure that all results from your discussions are visualised in the evacuation map. This map will be a reference and planning tool for emergency managers and involved institutions. As it includes information, not all of which may be relevant for the general public, it is suggested to develop a simplified version for public information.
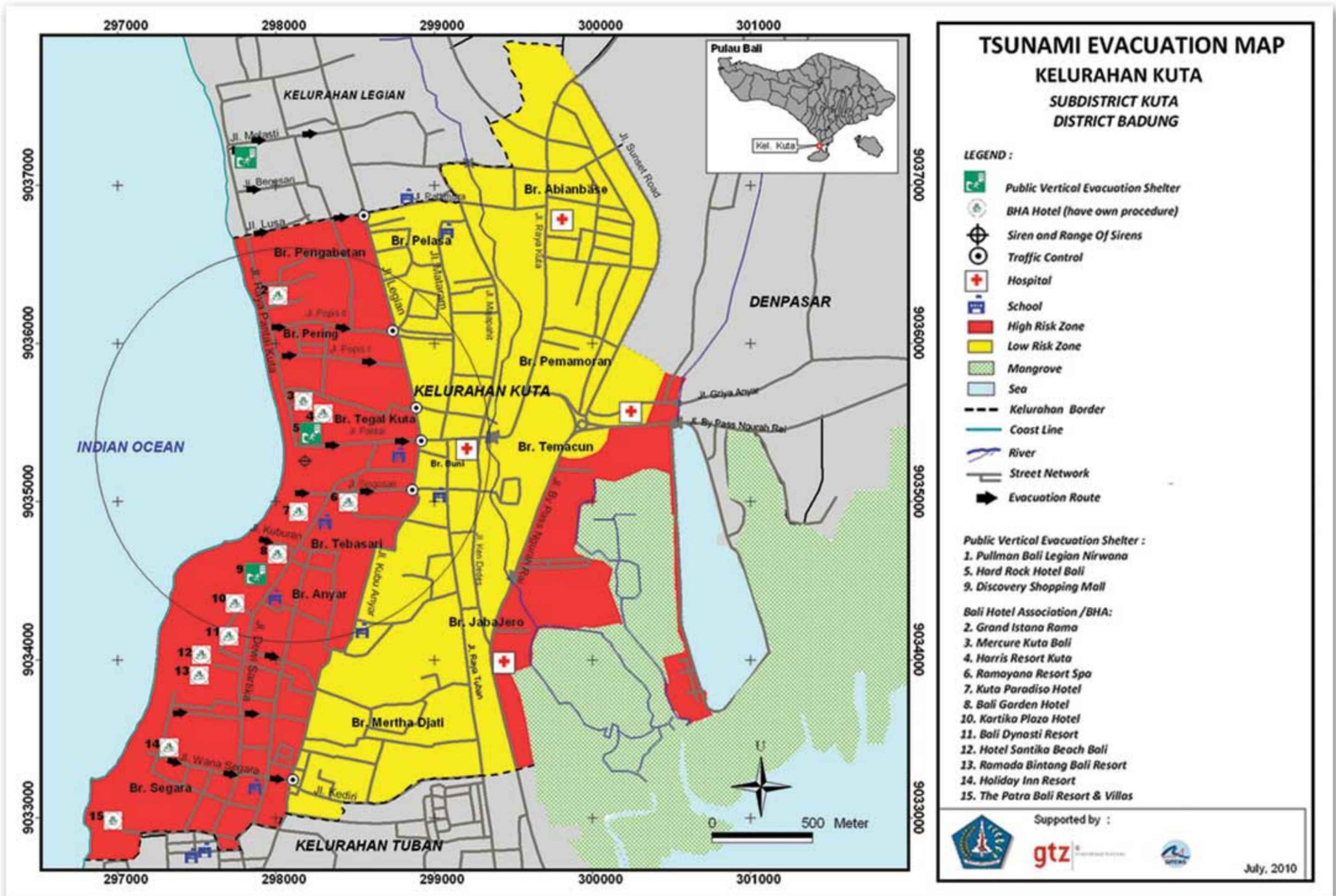
The map for public information (right) in Kelurahan Kuta, Bali, has been simplified by leaving out some technical aspects (e.g., traffic control points, hotels with their own procedures, etc.) from the map on the left. Furthermore, the street network on the community map has been redesigned, focusing on the agreed evacuation routes. Additional well-known landmarks have been included for easier orientation.

TSUNAMI EVACUATION MAP

■ High Risk Zone	▨ Mangrove	✚ Hospital	▣ Grand Istana Rama
■ Low Risk Zone	▢ Sea	▥ School	▣ Kuta Paradiso Hotel
➤ Evacuation Route	⦧ River	■ Bali Bombing Memorial	▣ Kartika Plaza Hotel
▣ Public Vertical Evacuation Shelter	▬ Street Network	▣ Matahari Square	▣ Holiday Inn Resort
⊕ Siren and Range of Sirens	- - Kelurahan Border	▣ Bali Mall Galeria	▣ The Patra Bali Resort and Villas

We recommend that you summarise all information in a simple, but complete, tsunami evacuation plan document. The following outline may be of use:

1) Introduction
2) General consideration for tsunami evacuation planning in the area
3) Brief description of the area
   - E.g., geography and population data, tsunami risk (hazard and vulnerability)
4) Evacuation strategy
   - Evacuation zones
   - Modes of evacuation
   - Evacuation routes
   - Local warning arrangements and reaction strategy (when to evacuate?)
   - Roles and responsibilities of different actors
   - Evacuation signage
5) Recommendations for next steps
   - Assessment of potential assembly areas
   - Assessment of potential evacuation shelter buildings
   - Dissemination of evacuation plan to all relevant stakeholders and vulnerable facilities
   - Outreach activities to strengthen public knowledge and awareness
   - Tsunami simulations exercises
6) Evacuation maps and information material

STEP 4:
Assess, endorse and disseminate your evacuation plan

The goal of Step 4 is to finalise your tsunami evacuation plan and to distribute it to your community. This includes the dissemination of the plan to all government and non-government institutions, vulnerable facilities and their related institutions, all other stakeholders you consider relevant, and the general public.

Before you disseminate the plan, it is recommended that you gather your community's views about its usefulness. This will help you to improve it. Then, the local authority or institution in charge should endorse the plan. Once this is done, you can disseminate it. The following section will guide you in the dissemination process.

Public assessment of your evacuation plan

The best way to check whether your tsunami evacuation plan, especially the evacuation map and the procedures, is useful to your community is to involve them directly in the assessment process. Meetings with formal and informal community representatives in a *kelurahan* or village can serve this purpose. You may also approach a number of individual households to get feedback on the usefulness of the evacuation plan. The options depend on the time and resources you want to invest. Meetings with representatives may be quicker than visiting single households.

When assessing the usefulness of your evacuation map and procedures with the community you may ask the following questions:

■ Does the tsunami evacuation plan clearly indicate the hazard and evacuation zones, as well as the safe area?

■ Does the tsunami evacuation plan tell you clearly how to get to the safe area or an evacuation shelter building?

■ Do you think the tsunami evacuation plan uses realistic evacuation routes?

■ Does the tsunami evacuation plan tell you how you can get official warnings and guidance?

■ Does the tsunami evacuation plan tell you when to evacuate?

■ Does the tsunami evacuation plan tell you how to evacuate?

■ In general, what do you like about the tsunami evacuation plan?

■ How could the tsunami evacuation plan be improved?

A good way to discuss these questions is to use the tsunami evacuation map that already includes explanations on evacuation strategy and procedures, i.e., when and how to evacuate. You can use the results from the discussions with the community to improve the overall visualisation of your evacuation map, include additional evacuation routes and improve the explanation of procedures.

1. Get prepared, long before anything happens
- Study the evacuation map and get familiar with the evacuation procedures
- Discuss procedures within your family and neighbourhood
- Participate in drills and information events
- If you are a visitor to Bali, please check with your hotel for procedures

2. If you feel an earthquake, protect yourself
- Don't panic!
- Drop, cover and hold!

3. After an earthquake, be aware that a tsunami may follow
- Move away from the beach immediately as a precautionary measure!
- After strong and prolonged ground shaking, don't wait for an official warning. Leave the RED ZONE immediately!
- Listen to announcements from the local authorities and the radio for further information. Pay attention to the siren!

4. The sound of the siren is the official call for evacuation
- When the siren sounds, evacuate the RED ZONE immediately, or look for shelter in higher buildings!
- If you are in the YELLOW ZONE, seek shelter on higher floors
- If you are a visitor in a hotel, follow the instructions of hotel staff

After the first tsunami wave, more waves are likely to come!

Wait for an official "All Clear"

Public tsunami evacuation map and procedures for Kelurahan Kuta, Bali

Endorsement of your evacuation plan

The tsunami evacuation planning team already represents a wide range of local stakeholders, including representatives from government institutions. Such participatory involvement indicates strong ownership in the community and gives your effort credibility. Ownership and credibility is important when proceeding to the next step, which is official endorsement of the tsunami evacuation plan. Endorsement of the evacuation plan by the local authority is necessary before it is disseminated to the public, as the plan defines the official policy for tsunami evacuations, including official evacuation orders and announcement of the local emergency status.

The evacuation plan can be endorsed by a decree (*Surat Keputusan or Peraturan Gubernur/Walikota*) or local regulation (*Peraturan Daerah*). Given that official tsunami evacuation is under the authority of the district head (*Bupati*) or the mayor (*Walikota* and, in some cases, the governor), the evacuation plan is preferably endorsed at these levels. However, to achieve this level of legalisation is not always easy

and takes time. Endorsement by BPBD or *Kesbanglinmas* may be sufficient. As the institution assigned to deal with disaster management, BPBD or *Kesbanglinmas* should take the initiative and lead the process for the endorsement of the evacuation plan. It is recommended to get some kind of official and written endorsement by these institutions before disseminating the plan. This may be in the form of a foreword to the tsunami evacuation plan document and an official statement on the evacuation map.

Dissemination to institutions and other stakeholders

Following the endorsement, you need to introduce the tsunami evacuation plan to all stakeholders. Government institutions and NGOs involved in warning dissemination, evacuation support, community preparedness activities, and emergency response must be officially informed. These institutions have practical needs to adjust their operational procedures to the official evacuation plan.

In addition to this, all vulnerable facilities that you identified and mapped in Steps 2 and 3 must have access to the plan to take their own preparedness steps in accordance with the official evacuation plan. This includes (Setiadi, 2010, forthcoming):

- Installation of communication devices that enable direct reception of official warnings and guidance from BMKG and local authorities (i.e., FM and VHF radios, sirens, etc.);

- Installation of internal communication devices to disseminate warnings and evacuation guidance to staff, as well as users and visitors of the facilities (i.e., loudspeakers, VHF radios and traditional devices, such as drums, etc.);

- Development of standard procedures for the case of an earthquake and tsunami evacuation, including agreements, roles and responsibilities of staff, and institutional evacuation map;

- Activities to raise awareness amongst staff and facility users, including evacuation exercises.

You may call for a meeting with representatives from all relevant sectors (education, health, transportation, etc.) to discuss the plan, and decide on follow-up and planning support for these facilities.

Developing evacuation procedures in schools

There are several modules for raising awareness of tsunami risk in Indonesian schools. The tsunami module, *Disaster Awareness in Primary Schools* (DAPS), developed by the "Science Education Quality Improvement Project", which was implemented by the Ministry of Education and GTZ, is one of them. Besides presenting general knowledge of tsunami risk, it provides step-by-step guidance for evacuation planning in schools. You may use the module in cooperation with the education department and encourage schools to develop their own procedures based on the official evacuation plan. The DAPS manual can be downloaded from: www.gitews.org/tsunami-kit. DAPS was used in a number of elementary schools in Java, Sumatra and Bali, and improved based on users' input. For further information, contact the Indonesian Red Cross "School Awareness Group" in Bali via info@pmibali.or.id.

Development of school evacuation plan in Tanjung Benoa, Bali

Dissemination to the general public

There are numerous ways to disseminate a tsunami evacuation plan to the public. Some of them are described below. When designing an outreach strategy for your tsunami evacuation plan you should use the knowledge of your community's tsunami preparedness and readiness to evacuate that you gathered in Step 2. Outreach activities should be tailored to the state of knowledge and awareness of the tsunami risk in your community.

Community meetings

Discussing the tsunami evacuation plan directly with the local population may be the most effective way to encourage community preparedness. Community meetings can be used to raise people's awareness of their personal exposure and tsunami risk, explain the tsunami evacuation plan and get feedback, answer questions and encourage residents of villages or urban neighbourhoods to develop their own procedures. During these community events, additional smaller evacuation routes and the need for additional warning communication devices (e.g., linking mosque loudspeakers to the local warning-centre) can be identified. The opportunity should also be used to promote neighbourhood and family response plans that enable people to evacuate independently at any time and provide support to those who are not able to evacuate on their own.

The size of these meetings depends on the neighbourhood unit you choose. You may hold meetings in hamlets (*dusun*) or smaller neighbourhood units, i.e., RW or RT, depending on the local conditions in your area. Close cooperation with local community representatives

in the preparation of these meetings is important. Ensuring their active involvement in the meeting increases ownership and credibility. Make sure that all meetings are open to everyone in the community.

Community meeting in Kelurahan Kuta, Bali

Community meetings that are just a one-time event may not be effective, as community preparedness is a long-term process, which eventually must be developed from within the community. Committed individuals and community volunteers can make a difference. The GTZ IS-GITEWS project developed a training and community outreach approach that aims to enable interested community volunteers to facilitate the preparedness process at the grass-roots level. It is called *Sadar Tsunami* (DarMi, "tsunami aware") and consists of two parts: a module for the training of community-based facilitators and a module for the organisation and implementation of community events (accessible through: www.gitews.org/tsunami-kit). It provides knowledge about tsunami risk, explains natural warning signs and discusses local warning arrangements. It also provides the opportunity to discuss the official tsunami evacuation plan and to develop local evacuation procedures. DarMi can be used for general community meetings or to address particular groups, such as beach vendors and members of SAR. It offers various outreach materials, such as films, a poster and a comic, and encourages interaction between the facilitator, the community and local government representatives in order to reach common solutions for better preparedness.

Dissemination media and channels

Aside from organising community events to communicate the evacuation plan, various outreach materials are required to increase people's knowledge and awareness. Each selected media should consider the target group's needs, as well as the advantages and the likely weaknesses of the media. Installation of billboards, signs or posters in the most frequently visited points can be effective. These types of signs may be retained for a reasonable period of time. They may be posted in tourist areas, markets, schools, crossroads, or the middle of town. Distribution of leaflets or flyers may be appropriate as well. Implementing a media campaign by using radio and TV broadcasts has the advantage of reaching a wide audience. Radio and TV shows can also be interactive, which enables an exchange of knowledge and experiences.

Evacuation signboard and information flyer from Sanur, Bali

The media must provide clear information that is easy to understand, is eye-catching and smartly designed to attract attention and be memorable. Wherever possible, it is recommended to involve communication experts in your effort to produce outreach materials that explain the tsunami evacuation plan effectively and raise people's awareness of the tsunami risk.

The output of this step is an endorsed public evacuation plan, as well as a strategy and work plan on how to disseminate your evacuation plan, and what information and outreach materials need to be produced. If you decide to have a media campaign through radio and TV, additional preparations must be made.

Work plan for community awareness events in Kelurahan Kuta, Bali

STEP 5:
Test, evaluate and improve your evacuation plan

You need to test your tsunami evacuation plan to know whether or not it is effective. Tsunami simulation and evacuation exercises reveal whether an evacuation plan is realistic and useful, i.e., if it serves the ultimate goal of getting people out of harm's way in time. Tests also provide momentum to increase overall tsunami awareness. When evaluated thoroughly these exercises enable you to improve your plan in accordance to the needs of the community and its institutions. You may follow the guidance in this section to give your evacuation plan a reality check and raise tsunami risk awareness in your community.

Test your tsunami evacuation plan

Tsunami simulation exercises imitate a real tsunami event, which is defined by a pre-determined scenario (i.e., a particular earthquake and tsunami warning). There are different types and scales of tsunami simulations. Some test only your community's capability to respond to warnings and to evacuate; others include testing of national and local early warning arrangements. Simulations may only test tsunami evacuations or also include emergency response measures after a tsunami. Depending on your particular objective and resources, you may choose between different options.

Small evacuation exercise

This type of exercise tests the capability of the public to respond to an earthquake and to evacuate tsunami hazard areas. It can be done without the dissemination of an official test alert by national or local institutions. When disseminating the tsunami evacuation plan to the institutions and facilities of your community, you should promote these exercises, provide advice on how to conduct them and get involved in the preparation, implementation and evaluation. The most important thing is that these exercises are done in a realistic manner simulating the conditions after an earthquake, especially with regards to the limited time for evacuation—and that evacuation procedures are improved based on the exercise.

Conducted in selected neighbourhoods, schools, hospitals, and other public facilities, evacuation exercises raise people's awareness and train them in evacuation procedures. These exercises need only a small budget and can be done regularly once or twice a year.

Tsunami evacuation exercise in a school in Padang

Tsunami drill

As the largest of all tsunami simulation exercises, a tsunami drill tests and aims to improve the end-to-end warning system: warning dissemination and the capability of institutions and the public to respond to natural and official warnings. It is conducted in "real time", employs real equipment, and tests all functions. It may involve the National Tsunami Warning Centre at BMKG in Jakarta to provide a scenario and send test warning messages that are then followed-up by local institutions, such as BPBD and *Pusdalops*. You may also conduct a tsunami drill by only involving local institutions. The implementation of the drill can be limited to only a small number of communities (e.g., villages, urban neighbourhoods) that have been involved in preparedness activities and are ready to test their evacuation plans.

A tsunami drill may include the participation of a larger number of local stakeholders, ranging from the local authorities (*Bupati* or *Walikota*, the military commander and police chief, etc.), government institutions and NGOs to the people in the risk areas. Preparation for a drill takes longer (up to six months) and requires significantly more resources than a simple evacuation exercise in a school or hospital. It is advisable that tsunami drills are well-planned and communicated to all participants beforehand to assure effective coordination and support from all stakeholders.

Tsunami drill in Bantul, Java (2008)

Evaluate the test results

Independent of the type of tsunami simulation exercise you choose, it should be evaluated thoroughly and the results should be used to improve evacuation plans and procedures.

The implementation of an end-to-end tsunami drill is a valuable experience for the local stakeholders and external community since the exercise demonstrates the local warning mechanism and response

capacity. This experience provides many lessons to learn and it should be clearly documented. To ensure the effectiveness of the lessons, internal and external observers should evaluate the exercise. Critical local practitioners (BPBD, *Kesbanglinmas*, the Red Cross, academicians, NGOs, etc.) may be selected as internal observers, while external observers may come from provincial (BPBD, *Kesbanglinmas*) and national institutions (e.g., BNPB, BMKG, LIPI, and others).

Evaluation of the tsunami drill in Bantul, Java

The evaluation of any evacuation exercise or drill should follow a clear methodology that uses social science methods for observation and evaluation. Observation sheets and checklists help to document the findings and evaluate them. All the observers should be briefed regarding the points to evaluate and how to measure them. The main objective is to use the results of the evaluation to improve the local preparedness components. Therefore, the local stakeholders should be informed of the results, which should be followed-up. Depending on the scale and purpose, the following aspects, amongst others, need to be evaluated:

People's capability to evacuate

- Reaction to simulated earthquake (e.g., time and effectiveness of reaction),
- Access to official warning and guidance (e.g., coverage with warning devices),
- Plausibility of official warning and evacuation guidance
- Overall evacuation process.

Public notification and communication between institutions

- Capability of BPBD/Pusdalops (or other local warning institution) to receive the tsunami warning from BMKG,

- Capability of BPBD/Pusdalops (or other local warning institution) and local authorities to make a quick decision on evacuation guidance,
- Capability of BPBD/Pusdalops (or other local warning institution) and local authorities to disseminate warning and evacuation guidance widely,
- Effectiveness of coordination and communication between local government and non-government institutions.

Revision of evacuation plan

The local stakeholders should take a proactive role to discuss the evaluation results received from the observers and come up with a strategy to revise the evacuation plan. There may be points raised to improve the evacuation map and/or the evacuation strategy. The revision should be carried out shortly after the tsunami simulation exercise. All stakeholders and the community must be informed about the revised version of the evacuation map and the evacuation strategy. Regular exercise of your evacuation plan is recommended because continuous simulation strengthens local preparedness and response capacity.

Lessons from tsunami evacuation exercises (GTZ IS-GITEWS, 2010)

Objectives and resources determine scale. An end-to-end tsunami drill allows testing of all parts of the system and creates a momentum to raise public awareness of the importance of preparedness. Yet, it is costly and requires long-term preparation. A tabletop simulation is sufficient to examine institutional procedures. Small exercises that strengthen public response capability and involve single neighbourhoods or schools are less costly and can be conducted on a regular basis.

Test existing conditions and conduct authentic simulations. Tsunami simulation exercises test and evaluate procedures and communication technology that are already in place and the actual capability of institutions and the people to respond. Developing procedures, setting up communication equipment, and assigning responsibilities only for a simulation without ensuring its sustainability mean nothing for preparedness and might create inaccurate expectations by the public in the case of an emergency.

Do not expect perfect results and evaluate thoroughly. A tsunami simulation exercise is a test to see what works and what does not. An exercise is considered successful if it shows the aspects of preparedness that need improvement. Involving all stakeholders and external observers in the evaluation is the key to getting clear recommendations. The evaluation must employ a clear and adequate methodology at institutional and community levels to assess the effectiveness of response and the warning system. Proper documentation and follow-up on recommendations is vital.

Provide clear information to the public and all stakeholders before and after exercises. The role of the media in providing information to the public before an exercise is important to avoid public misperception and support public education. Results of an exercise should also be shared with the public.

Conduct tsunami simulation exercises regularly. Exercises provide an opportunity to train institutions and the public for emergencies. Trainings must be frequent. Depending on the available resources, end-to-end tsunami drills can be conducted annually. Smaller institutional or evacuation exercises can be conducted more often and in alternating locations (e.g., different schools, neighbourhoods, etc.) to increase coverage.

The question of incentives. There is debate about whether communities (and institutions) involved in a simulation exercise should be provided with special incentives for their participation. For day labourers, for instance, participating in an exercise might mean a considerable loss of income. Much work is needed to raise people's awareness about the benefits of participating in an exercise as a contribution to a well-prepared and safer community. This will considerably reduce the costs of full-scale exercises.

Output of Step 5: plan to test, evaluate and improve the evacuation plan

The output of this step is a strategy on how to test and evaluate your plan, and what resources and materials are required for implementation. The evaluation results are the reference to improve your tsunami evacuation plan for the sake of better tsunami preparedness in your community.

TPS
SD ...

TPS
SD KORIPAN
1.1 KM

TPS
SD ROJONITEN
1 KM

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5. Glossary

Assembly areas

Designated locations outside the tsunami inundation area that serve as escape destinations and a base for rescue and relief for evacuees (authors' definition).

Areas of high-risk

Areas of high-risk are areas that are difficult to evacuate. These are areas where people may not be able to reach an evacuation target point (i.e., a safe location) before the arrival of a tsunami (Hiroi, 2004).

Estimated time of arrival / tsunami arrival time (ETA)

Time of tsunami arrival at a fixed location as estimated from modelling the speed and refraction of the tsunami waves as they travel from the source. ETA is estimated with very good precision if the bathymetry and source are well known. The first wave is not necessarily the largest (UNESCO, 2006).

(Self-)Evacuation

Organised deployment of people out of an acute endangered area into a safe one where they are temporarily placed and looked after (CEDIM, 2005). Self-evacuation with respect to hazard from near-field tsunamis is defined as the process to decide and actually leave endangered areas upon experiencing ground shaking and observing other natural warning signs of an impending tsunami (authors' definition).

Evacuation map

A drawing or visual representation that outlines hazard and risk zones and designates limits beyond which people must be evacuated to avoid harm from tsunami waves (UNESCO, 2006).

Evacuation plan

An evacuation plan is an official document providing the base for collective voluntary removal from a hazard area and self-protection. In the event of a tsunami, the plan describes the process of response and elaborates the roles and tasks of different stakeholders in the particular area (authors' definition).

Evacuation planning

Evacuation planning must establish the legal basis for evacuation and any conditions that apply. The planning process should involve examining the component parts of the evacuation process and determining exactly what tasks need to be carried out once the decision for evacuation has been made. The main objective is the development of an evacuation plan (EMA, 2005).

Evacuation route

Evacuation route refers to an evacuation path designated by an official body (e.g., municipal government) that allows evacuees to reach an evacuation target point (Hiroi, 2004).

Evacuation shelter building

A building (or earthen mound) that has sufficient height to elevate evacuees above the tsunami inundation depth, and is designed and constructed with the strength required to resist the forces generated by tsunami waves (FEMA, 2006).

Evacuation signage

Evacuation signs are a permanent reminder of tsunami risk. They can be posted on beaches and at other high-risk areas, along major routes to be used for evacuation, and in safe gathering areas. Signs guide people to the shelter areas during a disaster and educate them about tsunami risk at other times (GHI, 2008).

Evacuation zone

The term is used in different ways. In New Zealand and in some US-American evacuation plans, the term is used to describe the affected area by tsunamis (hazard area). In Japan, it is used to describe the "possible risk areas related to tsunami inundation zone", whereas the new ISO standard for tsunami signage (ISO 20712-1:2008) defines the function of an evacuation area as "the location of a safe place/uphill area for evacuation to in the event of a tsunami". In this document, the term "evacuation zone" is used to describe the area that needs to be evacuated (IOC, 2009a; Kawata, 2004).

Exposure

People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest (UNISDR, 2009).

Flow depth

This is the tsunami water depth above land surface in case of inundation, and is a time dependent value, given in meters (UNESCO, 2006).

Hazard assessment

Documentation of tsunami hazards for a coastal community is needed to identify populations and assets at risk, and the level of that risk. This assessment requires knowledge of probable tsunami sources (such as earthquakes, landslides, volcanic eruptions, etc.), their likelihood of occurrence, and the characteristics of tsunamis from those sources at different places along the coast. For those communities, data of previous (historical and paleo) tsunamis may help quantify these factors. For most communities, however, only very limited or no past data exist. For these coasts, numerical models of tsunami inundation can provide estimates of areas that will be flooded in the event of a local or distant tsunami-genic earthquake or a local landslide (UNESCO, 2006).

Hazard map

Hazard maps provide qualitative and quantitative graphic information on potential natural hazards, e.g., by presenting the expected danger or maximum level of danger of the event (GTZ, 2004).

Horizontal evacuation

The mode of evacuation in which people move to areas further inland and on higher ground out of the tsunami inundation area (authors' definition).

Host community

A host community is a community that is not affected by the tsunami. Support arrangements with host communities should be made in advance to ensure mutual assistance, such as rescue units, equipment, etc., in the case of an emergency (authors' definition).

Inundation area

Area flooded with water by the tsunami (UNESCO, 2006).

Inundation length (or maximum)

The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline (UNESCO, 2006).

People-centred early warning

The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss. This definition encompasses the range of factors necessary to achieve effective responses to warnings. A people-centred early warning system necessarily comprises four key elements: knowledge of the risks; monitoring, analysis and forecasting of the hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received. The expression "end-to-end warning system" is also used to emphasise that warning systems need to span all steps from hazard detection through to community response (UNISDR, 2009).

Preparedness

The knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from, the impact of likely, imminent or current hazard events or conditions. Preparedness action is carried out within the context of disaster risk management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response through to sustained recovery. Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems,

and includes such activities as contingency planning, stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities. The related term "readiness" describes the ability to quickly and appropriately respond when required (UNISDR, 2009).

Public awareness

The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards. Public awareness is a key factor in effective disaster risk reduction. Its development is pursued, for example, through the development and dissemination of information through media and educational channels, the establishment of information centres, networks, and community or participation actions, and advocacy by senior public officials and community leaders (UNISDR, 2009).

Risk

The combination of the probability of an event and its negative consequences. The word "risk" has two distinctive connotations: in popular usage, the emphasis is usually placed on the concept of chance or possibility, such as in "the risk of an accident"; whereas in technical settings, the emphasis is usually placed on the consequences, in terms of "potential losses" for some particular cause, place and period. It can be noted that people do not necessarily share the same perceptions of the significance and underlying causes of different risks (UNISDR, 2009).

Risk assessment

A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods, and the environment on which they depend. Risk assessments (and associated risk mapping) include: a review of the technical characteristics of hazards, such as their location, intensity, frequency, and probability; the analysis of exposure and vulnerability, including the physical, social, health, economic, and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process (UNISDR, 2009).

Safe area

Safe areas are out of reach of probable tsunami inundation. In case of a horizontal evacuation they must be reachable by most people in the community within a reasonable length of time (GHI, 2008).

Tsunami simulation exercise

A training method that imitates a tsunami event in order to strengthen institutions' and/or communities' tsunami awareness and preparedness. Other related terms are Tabletop (Gladi Posko), General Rehearsal (Gladi Bersih), Tsunami Drill, and Full Scale Drill. These terms describe different types, stages and scales of tsunami simulation exercises (authors' defintion).

Vulnerable facilities

Facilities and infrastructure inside the tsunami inundation area that are frequented by a large number of people and require special procedures and preparedness for tsunami evacuations (authors' definition).

Vulnerability

The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Examples may include poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management. Vulnerability varies significantly within a community and over time. This definition identifies vulnerability as a characteristic of the element of interest (community, system or asset), which is independent of its exposure. However, in common usage, the word is often used more broadly to include exposure to natural elements (UNISDR, 2009).