3.2 Hazards, Risks and Countermeasures against Natural Disasters in Pilot Regions

This section discusses methodologies for the creation of hazard maps and risk maps for the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman) for 1) Flood disaster, 2) Sediment disaster, 3) Earthquake and 4) Tsunami disaster. Possible countermeasures against the disasters are listed in relation to the hazard maps and risk maps. Capacity development activities for counterpart members of the pilot regions by the initiatives of the JICA study team experts are also explained. Lastly, concepts for early warning system for the pilot regions are described.

3.2.1 General

1) Objectives of Creations of Hazard Map and Risk Map

The objectives of creation of hazard maps and risk maps are:

1) to identify the areas which are considered to be high-hazard and risk to natural disasters, and
2) to identify problems facing the area for consideration in the preparation of regional disaster management plan.

For creations of hazard map and risk map for the targeted disasters, simplified methodologies were applied for facilitating smooth technology transfer to the counterpart members of the pilot regions, since it is aimed at the counterpart members who are expected to absorb the methodologies in order to re-produce or improve the maps. It is expected that all the local governments in Indonesia (*e.g.* BPBD as disaster management agency, *etc*.) will prepare hazard maps and risk maps in terms of natural disasters based on these methods.

2) Definition of Risk, Hazard and Vulnerability

According to "Living with Risk" published by Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR) in 2004, Risk is defined as "The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions" and can be indicated by the formula below.

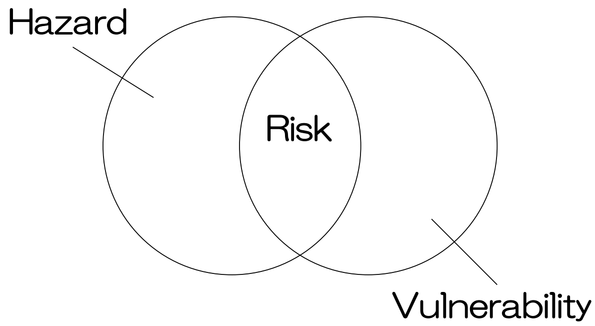
Risk = Hazard x Vulnerability (Eq. 3.1)

Hazard: A potentially damaging physical event, phenomenon or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

Vulnerability: The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

The definitions of risk, hazard and vulnerability above are the basis for the creation of hazard maps and risk maps. The relations among "Hazard", "Vulnerability" and "Risk" are shown as a conceptual figure (Refer to Figure 3.2.1), which is sourced from white book for disaster reduction (2006). According to the white book, the following terms are defined.

1. "Hazard", which is natural phenomena, is not controlled by people.
2. For example, "Vulnerability" can be reduced by means of promotion for anti-seismic housing/building construction, *etc*. against seismic hazard; hence the damage due to earthquake may be decreased considerably.
3. It is necessary to place more emphasis on disaster reduction activities in order to reduce "Vulnerability" prior to natural disaster event.



Source: White Book for Disaster Reduction in Japan, 2006 (Altered)

Figure 3.2.1 Relation among Hazard, Vulnerability and Risk

3) Flow Chart for Creations of Hazard Map and Risk Map

The conceptual flow chart for the creation of hazard map and risk map is shown in Figure 3.2.2 below. There are three (3) steps to producing a hazard map: namely 1) Data collection, 2) Calculation & Selection of indices and 3) Creation of Hazard map. Further, a risk map is derived based on the formula of "Risk = Hazard x Vulnerability" with the hazard map and the vulnerability indices (or possibly a map representing "Vulnerability"). At "Data collection" stage, the basic data in terms of hazard and vulnerability will be collected (*e.g.* affected disaster area, number of killed or injured, damage amount, rainfall, tidal level, surface ground condition, population, poverty rate, literacy rate, land use, *etc.*). Then, the indices for hazard and vulnerability will be calculated during the "Calculation & Selection of Indices" stage; they will be referred to as the candidate indices. The most appropriate indices for hazard and vulnerability can be selected amongst the candidate indices after the trial derivations of hazard map and risk map. It should be noted that some of the indices were selected based on the discussions with the counterpart organizations/members of the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman) during the workshops. After the selection of indices, the hazard map is created as the summation of the indices at the stage of "Creation of Hazard Map". The vulnerability map, consisting of the relevant selected indices, can be also created if necessary. Finally, the risk map will be created with the use of the formula of "Risk = Hazard x Vulnerability" as the result of the "Creation of Risk Map" stage.

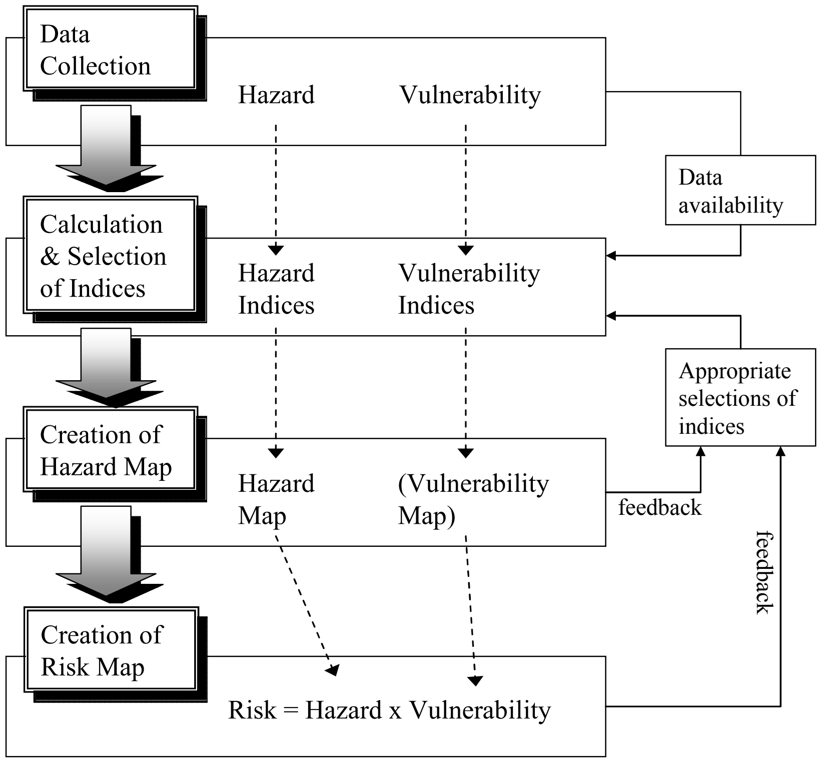


Figure 3.2.2 Conceptual Flow Chart for Creations of Hazard Maps and Risk Maps

Figure 3.2.3 shows the relations among risk, hazard, vulnerability, indices and basic data. "Risk" is composed of "Hazard" and "Vulnerability". "Hazard" and "Vulnerability" consist of their indices, respectively. "Hazard" is simply the summation of the hazard indices. "Vulnerability" can also be estimated in the same manner. Each index is derived or calculated based on the collected basic data (*e.g.* related documents, electric data, maps, *etc.*) from various information sources. The hazards and vulnerabilities are overlaid for analyzing the risk with the use of GIS (Geographical Information System) software. To overlay the maps, the maps are indicated in grid data, and then the maps are overlaid to calculate the risks. The applied size of the grid for Kabupaten Jember and Kabupaten Padang Pariaman were 1 x 1 km for the analyses. The grid size for Kota Pariaman was 500 x 500 m. Basically, the values of each layer were divided into five (5) classes indicating relative hazard/risk classifications. "Red" means the highest hazard/risk and "Orange" indicates higher hazard/risk. Moderate hazard/risk is shown in "Yellow" while "Green" means lower hazard/risk. Further, "Blue" shows the lowest hazard/risk.

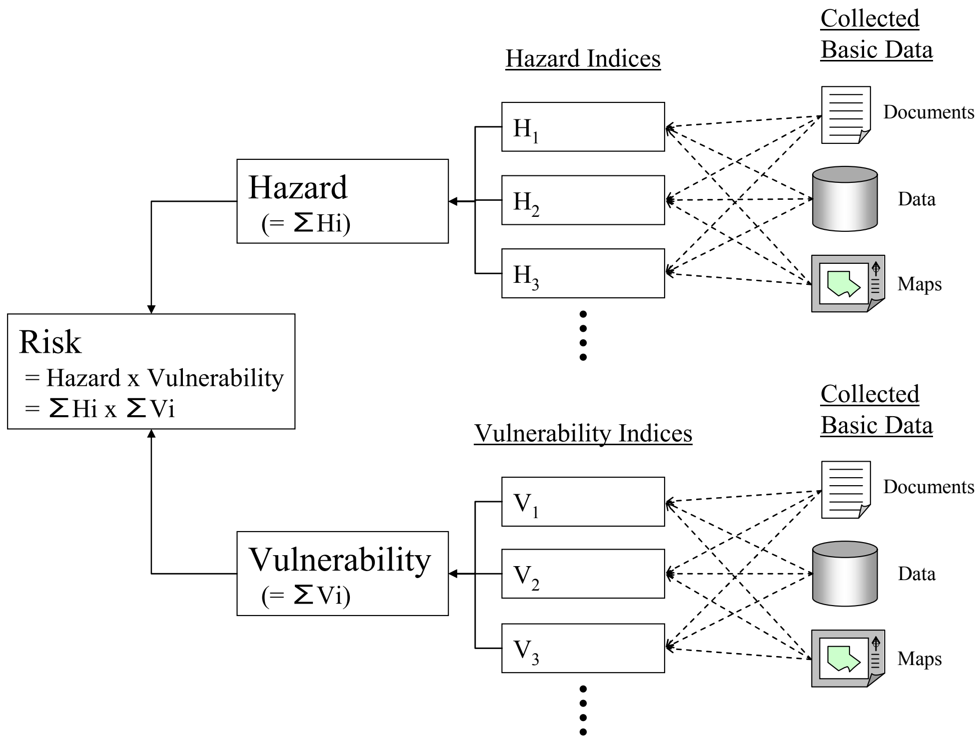


Figure 3.2.3 Relations among Risk, Hazard, Vulnerability, Indices and Basic Data

3.2.2 Flood disaster

This section describes the profile of hazard maps and risk maps for the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman) regarding flood disaster. Also,, the possible countermeasures against flood disaster are listed for the pilot regions. Lastly, capacity development activities for counterpart members are explained. More details are described in CHAPTER 6, Vol.3: Supporting Report.

1) Kabupaten Jember

A. Hazard Map for Flood Disaster

The flood hazard map for Kabupaten Jember was created based on flood maps or information provided from the relevant organizations of Kabupaten Jember through the close discussions between the experts of the JICA study team and the counterpart members of Kabupaten Jember during the several workshops or meetings. In other words, the flood hazard map was derived based on the combined result of the flood maps produced by National Unity and Public Protection Board, Irrigation Agency and Irrigation Board of Lumajang. Not only the flood area maps but also the data (*e.g.* flood depth, flood duration time, *etc*.) were desired to be obtained in order to estimate more precise indication of flood hazard in Kabupaten Jember. Such information could not be reflected for the creation of the flood hazard map, since they would not be obtained unfortunately during the study team activity in Jember. Then, flood hazard map for Kabupaten Jember was tried to be derived based on the combined result of the flood maps produced by National Unity and Public Protection Board, Irrigation Agency and Irrigation Board of Lumajang.

Refer to Figure 3.2.4 showing the flood hazard map for Kabupaten Jember. In the map, “Score 3 (Moderate Hazard)” was assigned to each of the flood hazard grids not differentiating the scores of flood hazard grids from Score 1 to Score 5 just like sediment disaster or tsunami disaster.

As shown in the figure, flood hazard areas are shown along Tanggul river, Bedadung river, Mayang river and Bondoyudo river especially in the alluvial low-lying area covering the central urbanized area to south-western area of Kabupaten Jember where the main land use is for paddy field. The most of the flood hazard areas in the alluvial low-lying area had been less than 2.0 degrees in slope covering the central urbanized area to south-west area of Kabupaten Jember. In other words, the area can be defined as “flood plain/flood prone area” from a technical viewpoint, where large amount of discharge is washed out in short time from “run-off source area” in steep sided mountains. Once the flood plain area is flooded, it may take longer time until flooded water subsided if there is no reliable drainage system.

In mountainous area in Kec. Silo, the hazard areas are shown as the recent banjir-bandan (flash flood with mud and debris) disaster on Jan. 7th, 2007. Some 70 houses were damaged due to the disaster. Further, Kec. Panti and Kec. Rambipuji were also seriously suffered from banjir-bandang disaster from Dec. 31st, 2005 to Jan. 2nd, 2006. A total of 108 people were killed and 11 agricultural intake facilities were damaged due to the disaster. The one of the main causes of the disaster was excessive rainfall amount. It should be noted that the area is on steep mountains, thus flood water washes out in a very short time.

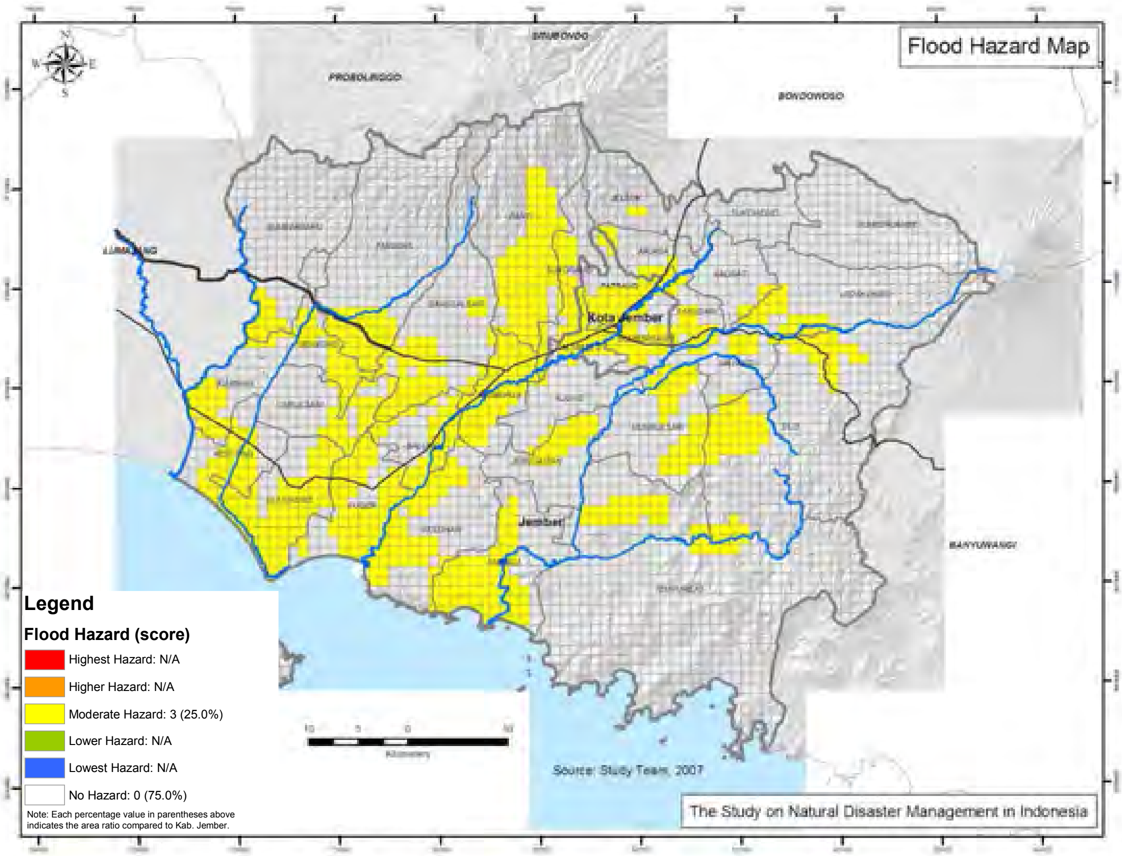


Figure 3.2.4 Flood Hazard Map for Kabupaten Jember

B. Risk Map for Flood Disaster

The indices used for the creations of flood hazard map and risk map are shown in Table 3.2.1. The details of vulnerability indices for "Population Density (V_{J1})", "Built-up Area (V_{J2})" and "Vegetation/Cultivated Area (V_{J5})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report.

The formula used for assessment of flood risk for Kabupaten Jember is shown below.

$$Risk = Hazard \times Vulnerability$$

$$Risk = H_{J7} \times (V_{J1} + V_{J2} + V_{J5}) \qquad \text{(Eq. 3.2)}$$

where H_{J7}: Index value of flood hazard, V_{J1}: Index value of population density, V_{J2}: Index value of built-up area and V_{J5}: Index value of vegetation/cultivated area.

Table 3.2.1 Indices Used for the Creations of Flood Hazard Map and Flood Risk Map

Hazard Index	Combined flood area based on the data or information collected from National Unity and Public Protection Board, Irrigation Agency and Irrigation Board of Lumajang (H_{J7})
Vulnerability Indices	1) Population Density (V_{J1}) 2) Built-up Area (V_{J2}) 3) Vegetation/Cultivated Area (V_{J5})

Refer to Figure 3.2.5 showing the flood risk map for Kabupaten Jember. Basically, higher risk area may be regarded as the area where population and property are concentrated, and exposed to flood hazard.

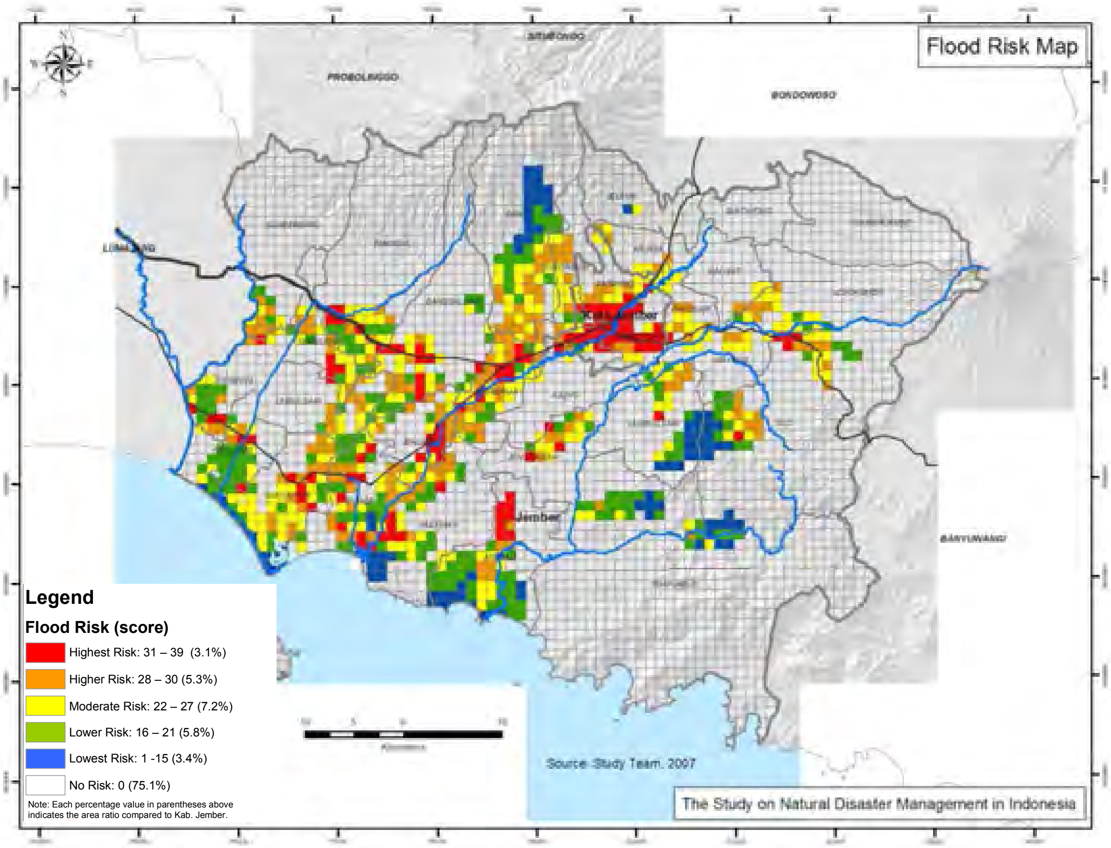


Figure 3.2.5 Flood Risk Map for Kabupaten Jember

As shown in the figure, the values of flood risk were divided into five (5) classes indicating relative risk classification. "Red" means the highest risk and "Orange" indicates higher risk. Moderate risk is shown in "Yellow" while "Green" means lower risk. Further, "Blue" shows the lowest risk. Overall trend covering Kabupaten Jember shows that the area, where population and property are concentrated along Tanggul river, Bedadung river, Mayang river and Bondoyudo river, are indicated as the higher risk of flood disaster. Highest risk indications can be seen in Kec. Kaliwates, Kec. Sumbersari and Kec. Patrang since the Kecamatans are located in urbanized and densely populated area in flood hazard. There are also the highest risk indications in Kec. Silo and some riverine areas along Tanggul river, Bedadung river, Mayang river and Bondoyudo river especially in the alluvial low-lying region covering the central urbanized area to south-western area of Kabupaten Jember.

C. Possible Countermeasures against Flood Disaster

On the basis of the hazard map and risk map, two areas were selected which have suffered from flood disasters in the past. The one is located in the eastern mountainous region, covering Kec. Silo and Kec. Mayang. (to be referred as “F1 Area” hereinafter). The other is located in F2 Area in the map, covering Kec. Jenggawah, Kec. Ambulu, Kec. Wuluhan, Kec. Balung, Kec. Puger, Kec. Gumukmas and Kec. Kencong. In this section, countermeasures against flood disasters are only described. Countermeasures against sediment disasters are explained in the corresponding section 3.2.3. Based on the flood disaster profiles mentioned above, the possible countermeasures for F1 Area and F2 Area are indicated in Table 3.2.2. It should be noted that the further analysis or investigation are necessary, since the following possible countermeasures are mainly based on the brief field reconnaissance in just couple of days and several discussions between the JICA study team members and the counterpart members (SATLAK) due to the limited time and resources allocated to this study.

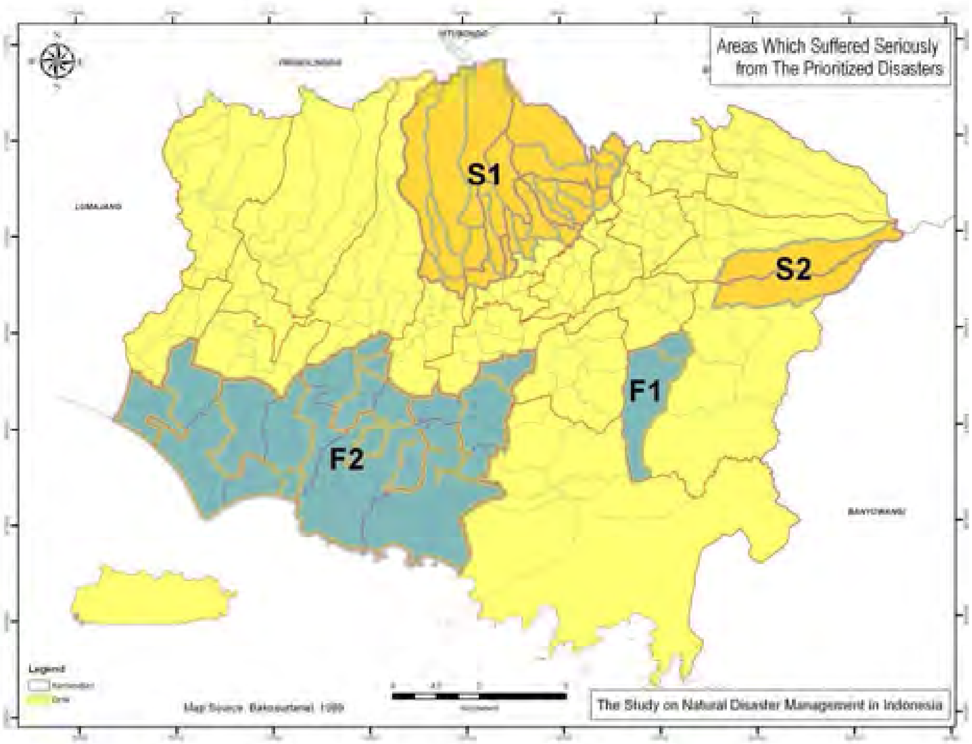


Figure 3.2.6 Areas which Suffered Seriously from Flood and Sediment Disasters

Table 3.2.2 Possible Countermeasures for F1 Area and F2 Area

	Non-structural Countermeasure	Structural Countermeasure
F1 Area	・ Reforestation ・ Land use limitation ・ Early warning system for fast and appropriate evacuation ・ Community activities ・ Evacuation shelter and route	・ Dike ・ Revetment works ・ Reinforcement of dike and revetment works ・ Channel excavation and widening ・ Bridge improvement (Raising, removal of bridge columns, etc.)
F2 Area	・ Land use limitation ・ Early warning system for fast and appropriate evacuation ・ Community activities ・ Evacuation shelter and route	・ Normalization of river course ・ Dike ・ Revetment works ・ Reinforcement of dike and revetment works ・ Excavation and widening of river course ・ Flood Control Facilities

All of the countermeasures indicated in the table above are expected to be implemented in order to minimize the damages due to flood disasters. In general, it requires much more resources (*e.g.* budget, man-months, technology, *etc.*) for the implementation of structural countermeasures than for non-structural countermeasures. Therefore, the implementation for the non-structural countermeasures with smaller budget should be prioritized for the time being. The above general policy should not impede the structural countermeasures with minimum budget which gives the significant beneficial effects from a viewpoint of disaster reduction. In the long run, cost effective strategic planning is indispensable in view of the implementation period, construction schedule, budgeting, capacity development, project management related to structural countermeasures and non-structural countermeasures. Prior to appropriate implementation of the countermeasures, formulation of master plan (M/P) or feasibility study (F/S) for disaster reduction in terms of flood disaster including sediment disaster as a part of Integrated River Basin Management (IRBM) are recommended to be carried out. Figure 3.2.7 shows the conceptual procedure for step 1, step 2 and step 3 for realization of “Safe Kabupaten Jember against Water-Related Disasters”.

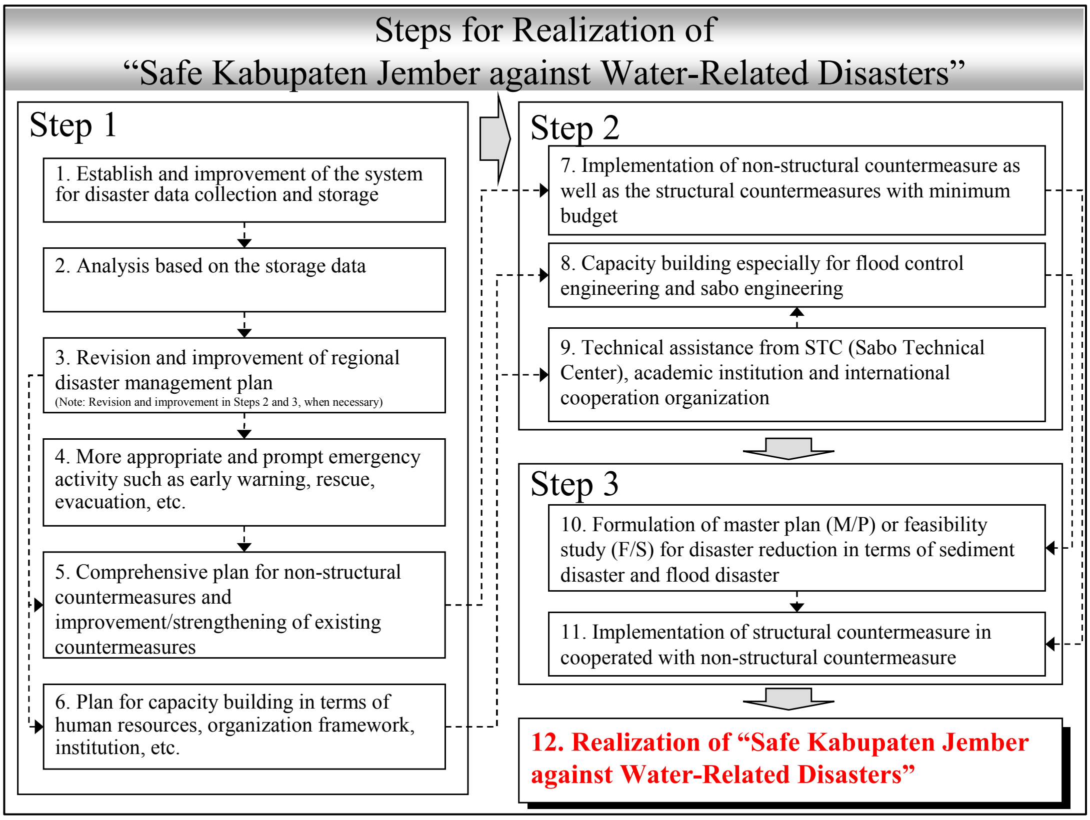


Figure 3.2.7 Steps for realization of "Safe Kabupaten Jember against Water-Related Disasters"

D. Activities for Capacity Development

The technical workshops for flood and sediment disasters as shown in the table below (Refer to Table 3.2.3) were held targeting at key persons from the related counterpart agencies of SATLAK, Kabupaten Jember, such as National Unity and Public Protection Board, Public Works Agency, Transportation Agency, Irrigation Agency, Agriculture Agency, Forestry and Plantation Agency as well as BMG Malang and, Irrigation Board of Lumajang.

Main objectives of the workshops were as follows:

- Strengthening of capacity of formulation and update of plan, especially for hazard and countermeasures
- Strengthening of capacity of implementation of measures
- Strengthening of capacity of coordination among organizations

In the series of workshops, many topics regarding flood and sediment disasters were discussed with participants, for example, a basic concept of hazard, risk and countermeasures, importance of management for disaster data/information, characteristics of resent disasters, selection of prioritized disaster prone area, concrete countermeasures, *etc.*

Owing to these continuous workshops, the awareness of the key persons was considerably raised for disaster reduction activities, which could be clearly confirmed from the results of questionnaires to the participants about the workshop. On the other hand, it was obvious through the discussion of the workshop that inter-organizational coordination is crucial for implementation of effective countermeasures or construction of infrastructure with regard to disasters. In order to plan and implement effective countermeasures against disasters, it is necessary that more close coordination and cooperation among the organizations concerned is made through further positive discussion.

Table 3.2.3 List of Technical Workshops for Counterpart Members of Kabupaten Jember

No.	Date	Place	No. of Participants	Contents
1	Sept. 7, '07	Conference room, Study Team office, PEMKAB, Jember	26	Introduction of countermeasures in Japan The present conditions and countermeasures against flood disaster in Japan, *etc.*
2	Sept. 20, '07	Conference room, Study Team office, PEMKAB, Jember	15	Briefing of creations of hazard map and risk map Outline of creating hazard map and risk map using GIS, rainfall measurement for warning and evacuation, *etc.*
3	Jan. 28, '08	Conference room, Study Team office, PEMKAB, Jember	10	Discussion on hazard map and risk map Discussion on creation method and validity of hazard map and risk map, *etc.*
4	Feb. 1, '08	Conference room, Study Team office, PEMKAB, Jember	9	Preparation of hazard map and risk map Understanding disaster characteristics in Kabupaten Jember and discussion of countermeasures
5	Feb. 5, '08	Conference room, Study Team office, PEMKAB, Jember	11	Countermeasures in prioritized areas (1) Selection of the priority areas and discussion of possible countermeasures against flood disasters
6	Feb. 12, '08	Conference room, Study Team office, PEMKAB, Jember (Field work)	10	Field Investigation Briefing of methodology to conduct field survey and implementation of sediment disaster field survey in Kecamatan Arjasa
7	Feb. 14, '08	Conference room, Study Team office, PEMKAB, Jember	9	Countermeasures in prioritized areas (2) Discussion on flood countermeasures in prioritized areas, *etc.*
8	Feb. 20, '08	Conference room, Study Team office, PEMKAB, Jember	8	Wrap Up Final discussion on flood disaster countermeasures and general overview of past workshops, *etc.*

2) Kabupaten Padang Pariaman

A. Hazard Map for Flood Disaster

The flood hazard map for Kabupaten Padang Pariaman was created based on data and information provided from the relevant organizations of Kabupaten Padang Pariaman and Pengelolaan Sumber Daya Air (PSDA) of West Sumatra Province through the discussions between the experts of the JICA study team and the counterpart members of Kabupaten Padang Pariaman. The indices used for creations of flood hazard map are indicated in Table 3.2.4. The indices of "Flatness" and "Alluvium" were adopted as indices of flood hazard, since low-lying area or alluvium flat plain can be the area of higher potential of flood disaster. The indices of "Flood depth" and "Flood duration" were also selected using data from Pengelolaan Sumber Daya Air (PSDA) of West Sumatra Province, since such data can also indicate higher potential of flood disaster.

Table 3.2.4 Indices Used for Creations of Flood Hazard Map

Hazard Indices	1) Flatness (Slope) (H_{P7}) 2) Alluvium (Geology) (H_{P8}) 3) Flood Depth (H_{P9}) 4) Flood Duration (H_{P10})

The formula used for assessment of flood hazard for Kabupaten Padang Pariaman is shown below.

$$Hazard = H_{P7} + H_{P8} + H_{P7} + H_{P10} \quad \text{(Eq. 3.3)}$$

where, H_{P7}: Index value of flatness, H_{P8}: Index value of alluvium, H_{P9}: Index value of flood depth and H_{P10}: Index value of flood duration.

Refer to Figure 3.2.8 showing the flood hazard map for Kabupaten Padang Pariaman. As indicated in the figure, the values of flood hazard were divided into five (5) classes indicating relative hazardous classification. The higher scores of flood hazard (in "Red" and "Orange") are concentrated in alluvial low-lying area along coastal line facing on the Indian Ocean in Kabupaten Padang Pariaman. Along the coastal line, the river mouths tend to be blocked by sand bars, beach ridges and sand dunes which may cause flooding from main rivers, poor drainage, forming marsh and thus higher potential of flooding. Especially, the low-lying area along the southern coastal line in Kecamatan Ulakan Tapakis may be significantly subject to the tendency, when the rainfall in the catchment is heavy and sea water level is at high tide, thus the resulting flood hazard is the highest (in "Red") compared to the other coastal low-lying area. Further, the higher scores for flood hazard (in "Red" or "Orange") are indicated in Kecamatan Batang Gasan and Kecamatan Sungai Limau along the northern coastal line, which are located in very narrow low-lying area between the coastal line and the terrace being formed along the fault line. Certain levels of flood hazards can be seen in some flat area along Anai river, Ulakan river, Tapakis river, Mangau river, Naras river and Gasan river.

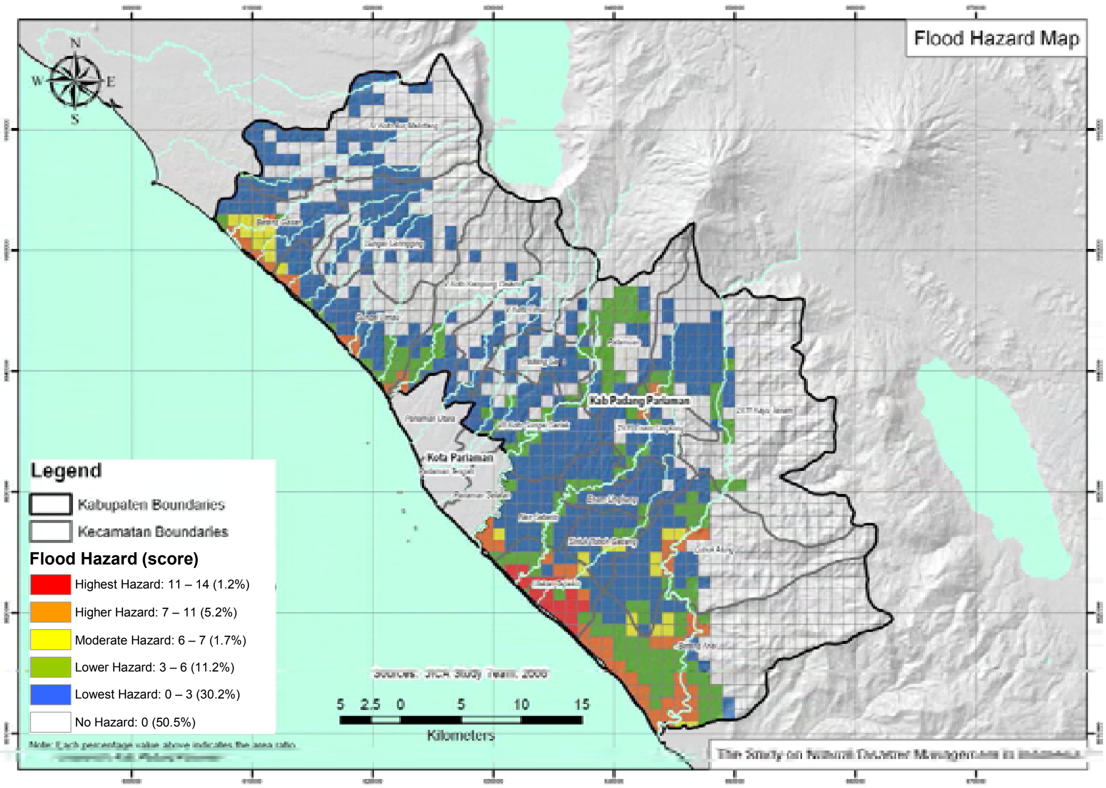


Figure 3.2.8 Flood Hazard Map for Kabupaten Padang Pariaman

B. Risk Map for Flood Disaster

The vulnerability indices are shown in Table 3.2.5. The details of vulnerability indices for "Population Density (V_{P1})", "Built-up Area (V_{P2})" and "Plantation and Rice-field Area (V_{P5})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report.

Table 3.2.5 Vulnerability Indices Used for Flood Disaster

Vulnerability Indices	1) Population Density (V_{P1}) 2) Built-up Area (V_{P2}) 3) Plantation and Rice-field Area (Land Cover) (V_{P5})

The formula used for assessment of flood risk for Kabupaten Padang Pariaman is shown below.

Risk = Hazard x Vulnerability

$$\text{Risk} = (H_{P7} + H_{P8} + H_{P9} + H_{P10}) \times (V_{P1} + V_{P2} + V_{P5}) \quad \text{(Eq. 3.4)}$$

where, H_{P7}: Index value of flatness, H_{P8}: Index value of alluvium, H_{P9}: Index value of flood depth, H_{P10}: Index value of flood duration,V_{P1}: Index value of population density, V_{P2}: Index value of built-up area and V_{P5}: Index value of vegetation/cultivated area.

The risk map for flood disaster in Kabupaten Padang Pariaman is shown in Figure 3.2.9. Basically, higher risk area may be regarded as the area where population and property are concentrated, and exposed to flood hazard. As shown in the figure, the values of flood risk were divided into five (5) classes indicating relative risk classification. Overall trend covering Kabupaten Padang Pariaman shows that relatively higher scores were observed in the southern part of Kabupaten (Kecamatan Name: Batang Anai, Lubuk Alung, 2x11 Kayu Tanam, 2x11 Enam Lingkung, Enam Lingkung, Sintuk Toboh Gadang, Ulakan Tapakis, Patamuan, Padang Sago and VII Koto Sungai Sariak) compared to the northern part (Kecamatan Name: V Koto Timur, V Koto Kampung Dalam, Sungai Limau, Sungai Geringging, Batang Gasan and IV Koto Aur Malintang). Especially, the most of the area adjacent to the river mouths along coastline of Anai river, Ulakan river, Tapakis river, Mangau river, Naras river and Gasan river are indicated in “Red” or “Orange”, which means the highest risk or higher risk. Certain levels of flood risk can be seen along Anai river, Ulakan river, Tapakis river, Mangau river and Naras river.

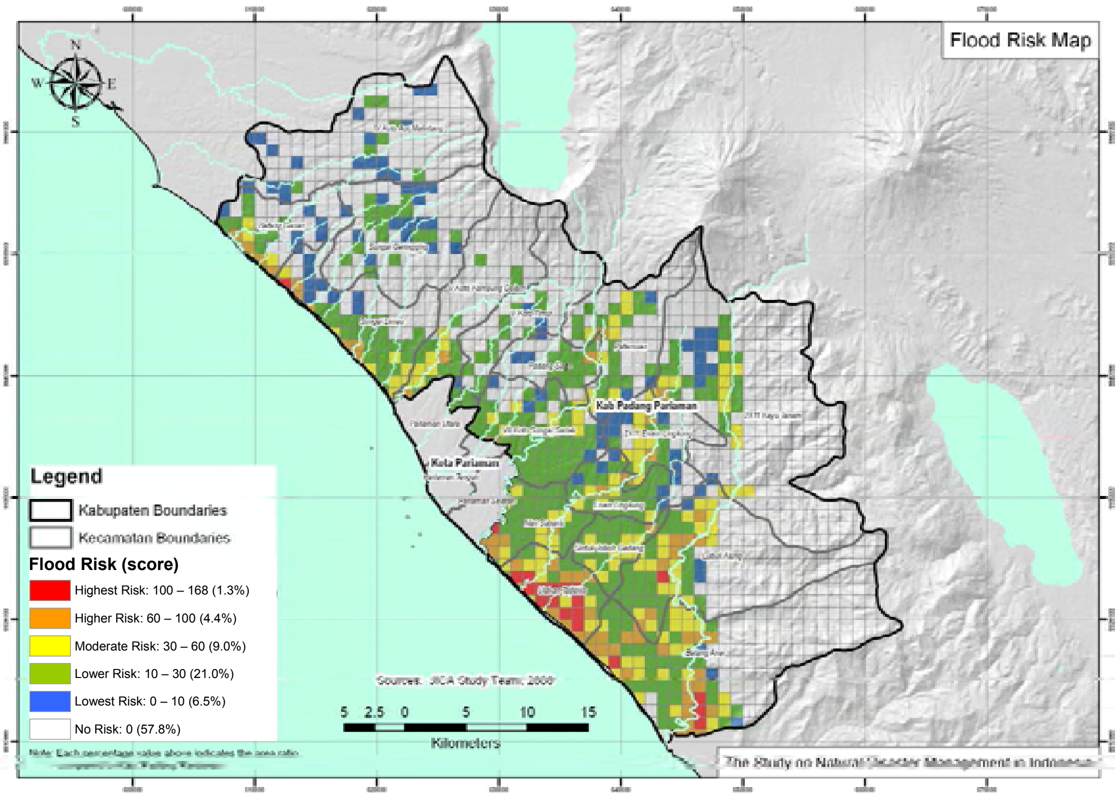


Figure 3.2.9 Flood Risk Map for Kabupaten Padang Pariaman

C. Possible Countermeasures against Flood Disaster

As indicated in Figure 3.2.8 and Figure 3.2.9, the higher or the highest score of flood hazard or risk tend to appear in alluvial low-lying area ("flood plain/flood prone area") along coastline facing on the Indian Ocean in Kabupaten Padang Pariaman. It may be necessary to differentiate "flood plain/flood prone area (downstream and estuary)" and "run-off source area (middle-reach to upstream area)" for planning of possible countermeasures against flood disaster. Figure 3.2.10 shows the possible countermeasures for "flood plain/flood prone area (downstream and estuary)" and "run-off source area (middle-reach to upstream area)" in Kabupaten Padang Pariaman including Kota Pariaman. Table 3.2.6 shows the possible countermeasures for each Kecamatan in Kabupaten Padang Pariaman. All of the countermeasures indicated in the table above are expected to be implemented in order to minimize the damages due to flood disasters. For realization of "Safe Kabupaten Padang Pariaman against water-related (Flood and Sediment disaster) disasters, the similar procedure to Kabupaten Jember is necessary to be implemented.

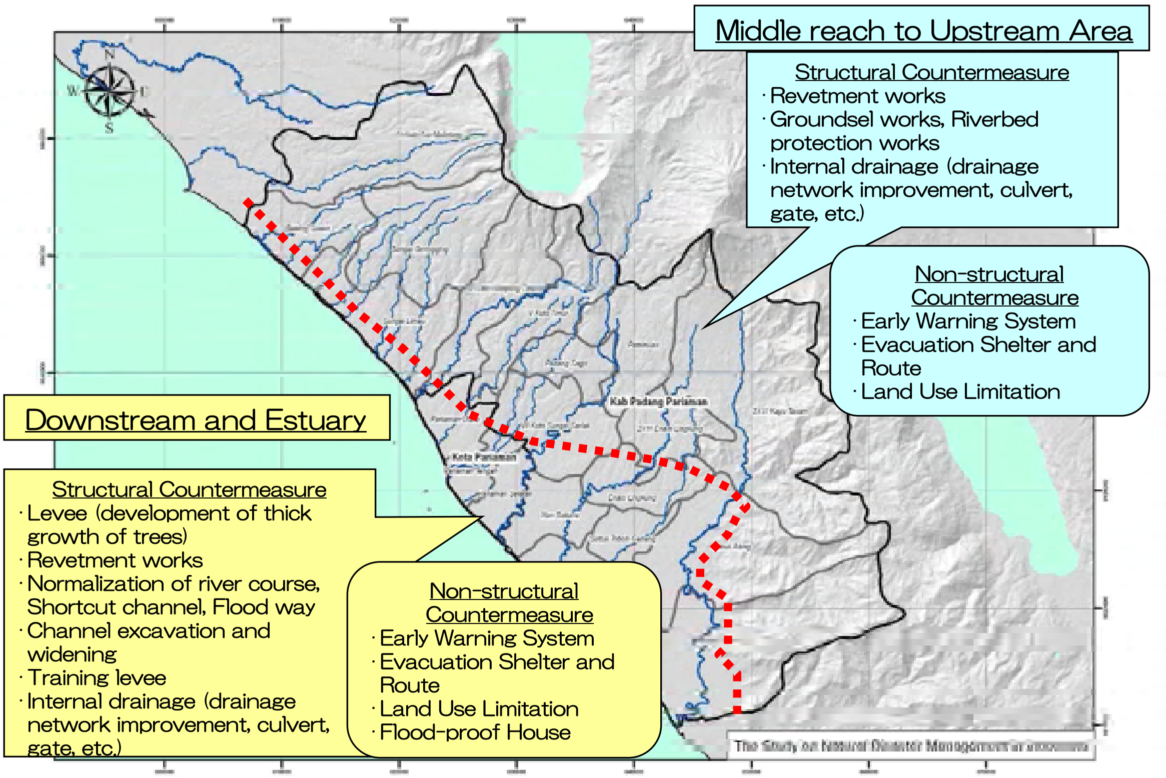


Figure 3.2.10 Possible Countermeasures against Flood Disaster for Kabupaten Padang Pariaman

Table 3.2.6 Possible Countermeasures for Kecamatans in Kabupaten Padang Pariaman

Kecamatan		Possible Countermeasures	
		Structural Countermeasures	Non-Structural Countermeasures
1	Batang Anai	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
2	Lubuk Alung	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
3	Sintuk Toboh Gadang	Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
4	Ulakan Tapakis	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
5	Nan Sebaris	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
6	2 x 11 Enam Lingkung	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route
7	Enam Lingkung	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route
8	2 x 11 Kayu Tanam	Revetment works Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route
9	VII Koto Sungai Sarik	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route
10	Patamuan	Revetment works Improvement of drainage system	Early warning system Evacuation shelter and route
11	Padang Sago	Revetment works Improvement of drainage system	Early warning system Evacuation shelter and route
12	V Koto Kampung Dalam	Levee Revetment works Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
13	V Koto Timur	Revetment works Improvement of drainage system	Early warning system Evacuation shelter and route
14	Sungai Limau	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
15	Batang Gasan	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
16	Sungai Geringging	Revetment works Improvement of drainage system	Early warning system Evacuation shelter and route
17	IV Koto Aur Malintang	Revetment works Improvement of drainage system	Early warning system Evacuation shelter and route

D. Activities for Capacity Development

The technical workshops for flood and sediment disasters as shown in the table below (Refer to Table 3.2.7) were held targeting at the counterpart members of disaster countermeasure team of Kabupaten Padang Pariaman including Kota Pariaman.

Main objectives of the workshops were as follows:

- Strengthening of capacity of formulation and update of plan, especially for hazard and countermeasures
- Strengthening of capacity of implementation of measures
- Strengthening of capacity of coordination among organizations

In a series of workshops, many topics regarding flood and sediment disasters were discussed with participants, for example, a basic concept of hazard, risk and countermeasures, importance of management for disaster data/information, characteristics of resent disasters, concrete countermeasures, *etc.*

Owing to these continuous workshops, the awareness of the participants was considerably raised for disaster reduction activities, which could be clearly confirmed from daily conversations with the participants about the workshop. On the other hand, it was obvious through the discussion of the workshop that inter-organizational coordination is crucial for implementation of effective countermeasures or construction of infrastructure with reference to disasters. In order to plan and implement the effective countermeasures against disasters, it is necessary that more close coordination and cooperation among the organizations concerned will be made through the further positive discussion.

Table 3.2.7 List of Technical Workshops for Counterpart Members of Kabupaten Padang Pariaman including Kota Pariaman

No.	Date	Location	No. of Participants	Contents
1	Jun. 11, '08	Conference room in Kabupaten Padang Pariaman office	11	Countermeasures in Japan The characteristics of flood and sediment disasters in Japan as well as countermeasures were introduced. Expected countermeasures in Kab. Padang Pariaman and Kota Pariaman were also discussed.
2	Jul. 3, '08	Field study	19	Joint Field Survey Counterpart members including disaster planning team and disaster countermeasure team from Kab. Padang Pariaman and Kota Pariaman participated the joint field survey. The survey was to facilitate understanding the physical aspects of natural disasters and possible countermeasures in terms of Tsunami Disaster, Earthquake, Sediment Disaster and Flood Disaster through the discussions between JICA Study members and Counterpart members during this field trip.
3	Sep. 8, '08	Conference room in Kota Pariaman office	9	Preparation of hazard map and risk map Procedures for creating hazard map and risk map were discussed as well as possible countermeasures.

3) Kota Pariaman

A. Hazard Map for Flood Disaster

The flood hazard map for Kota Pariaman was created based on data and information provided from the relevant organizations of Kota Pariaman and Pengelolaan Sumber Daya Air (PSDA) of West Sumatra Province through the discussions between the experts of the JICA study team and the counterpart members of Kota Pariaman. The indices used for creations of flood hazard map are indicated in Table 3.2.8. The indices of "Flatness" and "Alluvium" were adopted as indices of flood hazard, since low-lying area or alluvium flat plain can be the area of higher potential of flood disaster. The indices of "Flood depth" and "Flood duration" were also selected, since such data can also indicate higher potential of flood disaster, which were provided from Pengelolaan Sumber Daya Air (PSDA) of West Sumatra Province.

Table 3.2.8 Indices Used for Creations of Flood Hazard Map

Hazard Indices	1) Flatness (Slope) (H_{P7}) 2) Alluvium (Geology) (H_{P8}) 3) Flood Depth (H_{P9}) 4) Flood Duration (H_{P10})

The formula used for assessment of flood hazard for Kota Pariaman is shown below.

$$\text{Hazard} = H_{P7} + H_{P8} + H_{P9} + H_{P10} \qquad \text{(Eq. 3.5)}$$

where, H_{P7}: Index value of flatness, H_{P8}: Index value of alluvium, H_{P9}: Index value of flood depth and H_{P10}: Index value of flood duration.

Refer to Figure 3.2.11 showing the flood hazard map for Kota Pariaman. As indicated in the figure, the values of flood hazard were divided into five (5) classes indicating relative hazardous classification. The highest scores of flood hazard (in "Red") are concentrated in alluvial low-lying area along coastal line facing on the Indian Ocean in Kota Pariaman. Along the coastal line, the river mouths tend to be blocked by sand bars, beach ridges and sand dunes which may cause flooding from main rivers, poor drainage, forming marsh and thus higher potential of flooding. The low-lying area facing on coastal line in Kota Pariaman may be significantly subject to the tendency, when the rainfall in the catchment is heavy and sea water level is at high tide, thus the resulting flood hazard is the highest (in "Red"). Further, the moderate hazard scores (in "Yellow") are indicated in some law-lying alluvium flat plain along Mangor river, Mangau river, Pariaman river and Jirak river.

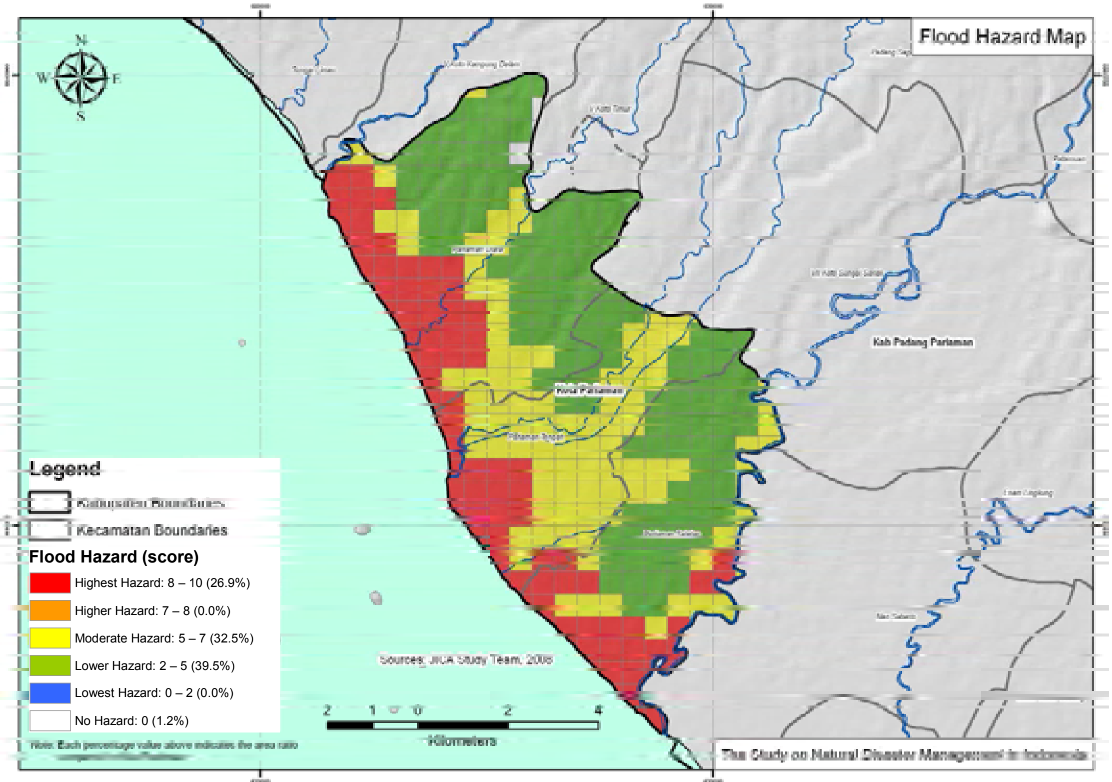


Figure 3.2.11 Flood Hazard Map for Kota Pariaman

B. Risk Map for Flood Disaster

The vulnerability indices are shown in Table 3.2.9. The details of vulnerability indices for "Population Density (V_{P1})", "Built-up Area (V_{P2})" and "Plantation and Rice-field Area (V_{P5})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report.

Table 3.2.9 Vulnerability Indices Used for Flood Disaster

Vulnerability Indices	1) Population Density (V_{P1}) 2) Built-up Area (V_{P2}) 3) Plantation and Rice-field Area (Land Cover) (V_{P5})

The formula used for assessment of flood risk for Kota Pariaman is shown below.

$$Risk = Hazard \times Vulnerability$$

$$Risk = (H_{P7} + H_{P8} + H_{P9} + H_{P10}) \times (V_{P1} + V_{P} + V_{P5}) \qquad \text{(Eq. 3.6)}$$

where, H_{P7}: Index value of flatness, H_{P8}: Index value of alluvium, H_{P9}: Index value of flood depth, H_{P10}: Index value of flood duration, V_{P1}: Index value of population density, V_{P2}: Index value of built-up area and V_{P5}: Index value of vegetation/cultivated area.

The risk map for flood disaster in Kota Pariaman is shown in Figure 3.2.12. Basically, higher risk area may be regarded as the area where population and property are concentrated, and exposed to flood hazard. As shown in the figure, the values of flood risk were divided into five (5) classes indicating relative risk classification. Overall trend covering Kota Pariaman shows that relatively higher scores were observed in the southern part of Kota compared to the northern part. The flood risk along coastal-line in Kec. Pariaman Tengah is the highest, since the area is under the highest flood hazard and highly populated urbanized area in Kota Pariaman.

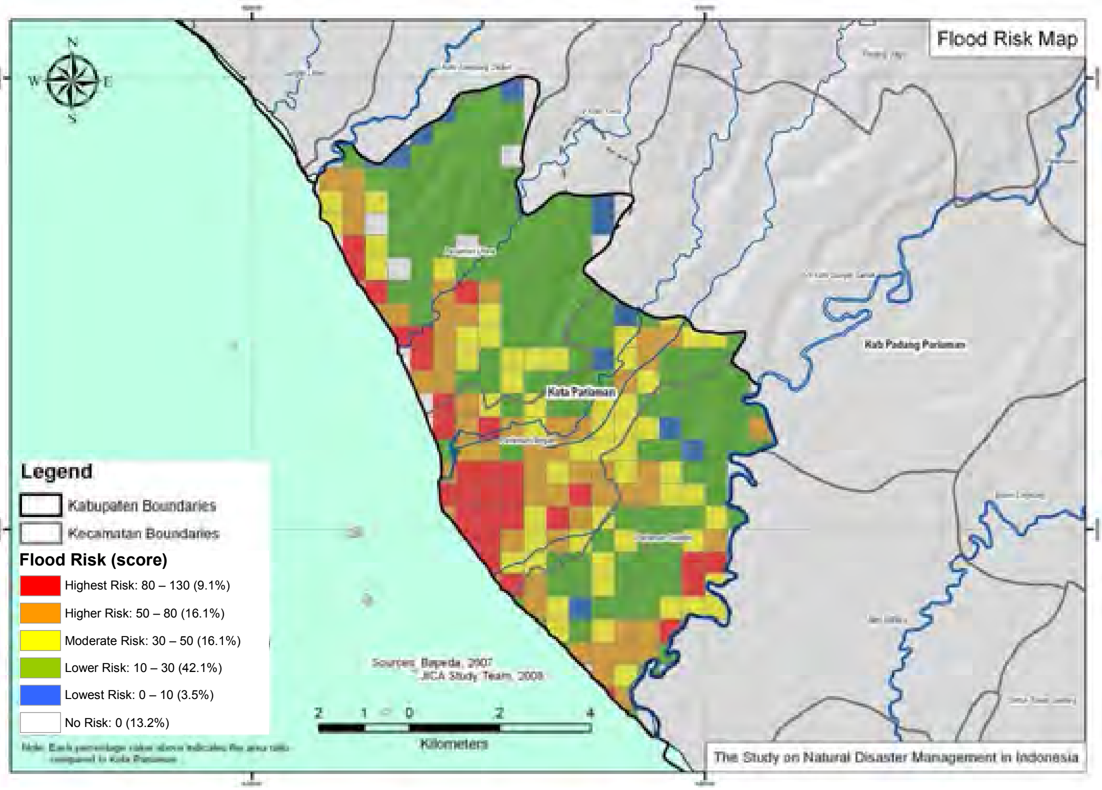


Figure 3.2.12 Flood Risk Map for Kota Pariaman

C. Possible Countermeasures against Flood Disaster

Refer to the corresponding section of Kabupaten Padang Pariaman. Table 3.2.10 shows the possible countermeasures for each Kecamatan in Kota Pariaman.

Table 3.2.10 Possible Countermeasures for Kecamatans in Kota Pariaman

Kecamatan		Possible Countermeasures	
		Structural Countermeasures	Non-Structural Countermeasures
1	Pariaman Utara	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
2	Pariaman Tengah	Levee Channel excavation and widening Normalization of river course Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house
3	Pariaman Selatan	Improvement of drainage system	Early warning system Land use limitation Evacuation shelter and route Flood-proof house

D. Activities for Capacity Development

Refer to the corresponding section of Kabupaten Padang Pariaman, since all the workshops for Kabupaten Padang Pariaman and Kota Pariaman were held at the same time.

3.2.3 Sediment disaster

This section describes the profile of hazard maps and risk maps for the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman) regarding sediment disaster. Also, possible countermeasures against sediment disaster are listed for the pilot regions. Lastly, capacity development activities for counterpart members are explained. The details are described in CHAPTER 5, Vol.3: Supporting Report.

1) Kabupaten Jember

A. Hazard Map for Sediment Disaster

The hazard map for sediment disaster in Kabupaten Jember was created based on data and information provided from the relevant organizations of Kabupaten Jember and BMG (Karangploso Station of Badan Meteorologi dan Geofisika) through the discussions between the experts of the JICA study team and the counterpart members of Kabupaten Jember. The indices used for creations of hazard map for sediment disaster are indicated in Table 3.2.12. The indices of “Slope”, “Geology” and “Annual Rainfall” were adopted as indices of sediment hazard.

Table 3.2.11 Indices Used for Creations of Sediment Hazard Map

Hazard Index	1) Slope (H_{J4}) 2) Geology (H_{J5}) 3) Annual Rainfall (H_{J6})

The formula used for assessment of sediment hazard for Kabupaten Jember is shown below.

$$\text{Hazard} = H_{J4} + H_{J5} + H_{J6} \qquad \text{(Eq. 3.7)}$$

where, H_{J4}: Index value of slope, H_{J5}: Index value of geology and H_{J6}: Index value of annual rainfall.

Refer to Figure 3.2.13 showing the sediment hazard map for Kabupaten Jember. As indicated in the figure, the values of sediment hazard were divided into five (5) classes indicating relative hazardous classification. In mountainous northern region, the hazard grids indicate the highest, which are due to 1) very steep slope in the mountainous area, 2) friable geology made of volcanic product and 3) heavy rainfall amount.

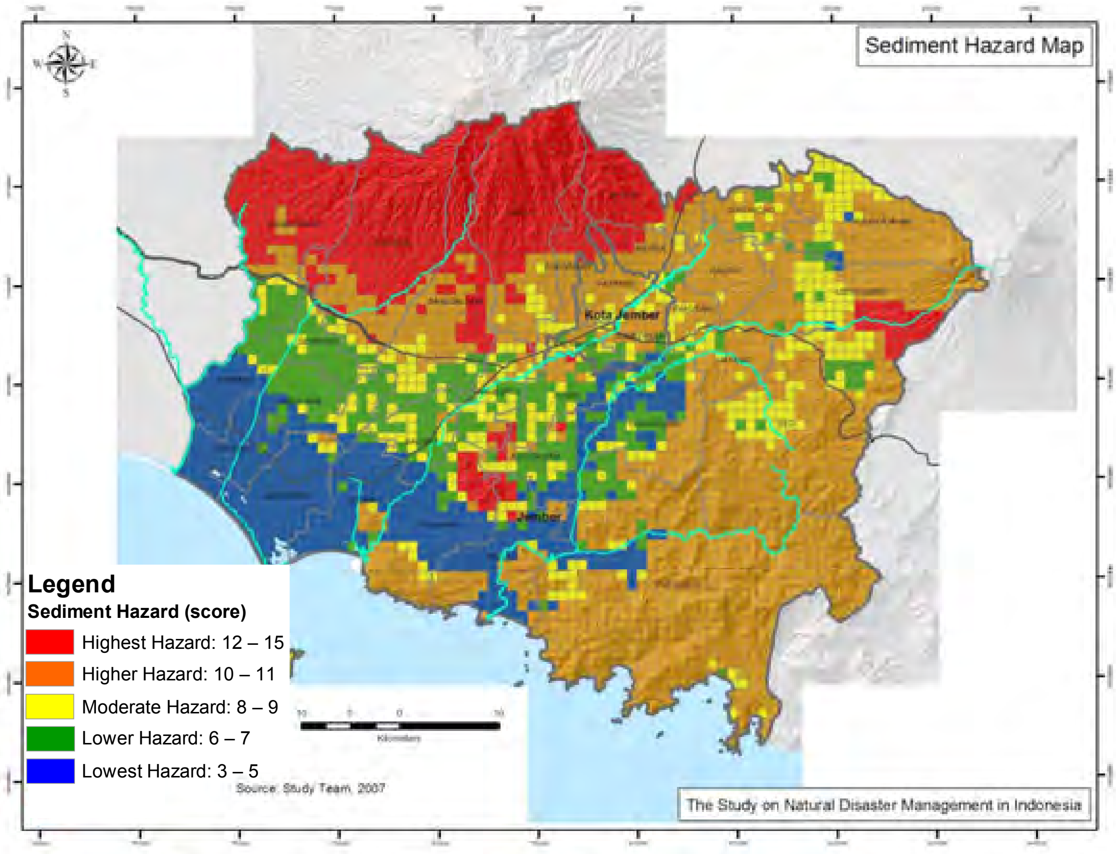


Figure 3.2.13 Sediment Hazard Map for Kabupaten Jember

B. Risk Map for Sediment Disaster

The vulnerability indices are shown in Table 3.2.12. The details of vulnerability indices for "Population Density (V_{J1})", "Built-up Area (V_{J2})" and "Land Cover (V_{J4})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report.

Table 3.2.12 Vulnerability Indices Used for Sediment Disaster

Vulnerability Indices	1) Population Density (V_{J1}) 2) Built-up Area (V_{J2}) 3) Land Cover (V_{J4})

The formula used for assessment of sediment risk for Kabupaten Jember is shown below.

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability}$$

$$\text{Risk} = (H_{J4} + H_{J5} + H_{J6}) \times (V_{J1} + V_{J2} + V_{J4}) \quad \text{(Eq. 3.8)}$$

where, H_{J4}: Index value of slope, H_{J5}: Index value of geology, H_{J6}: Index value of annual rainfall,V_{J1}: Index value of population density, V_{J2}: Index value of built-up area and V_{J4}: Index value of land cover.

Refer to Figure 3.2.14 showing the sediment risk map for Kabupaten Jember. Basically, higher risk area may be regarded as the area where population and property are concentrated, and exposed to sediment hazard. As indicated in the figure, the values of sediment hazard were divided into five (5) classes indicating relative hazardous classification. In the northern region, covering central urban area to the northern mountainous area, the risk grids tend to indicate the highest or higher level of sediment risk. Most of the central urban area including Kec. Kaliwates, Kec. Sumbersari and Kec. Patrang where are indicated as the highest risk. In the area, there are some steep slopes in residential area which may sometimes cause of sediment disaster. In north-western mountainous area including Kec. Panti and Kec. Rambipuji which were seriously suffered from banjir-bandang disaster from Dec. 31st, 2005 to Jan. 2nd, 2006, the most of the area is covered by volcanic products which are very friable in terms of geology and may cause serious sediment disaster to some of the densely populated area or to some agricultural products.

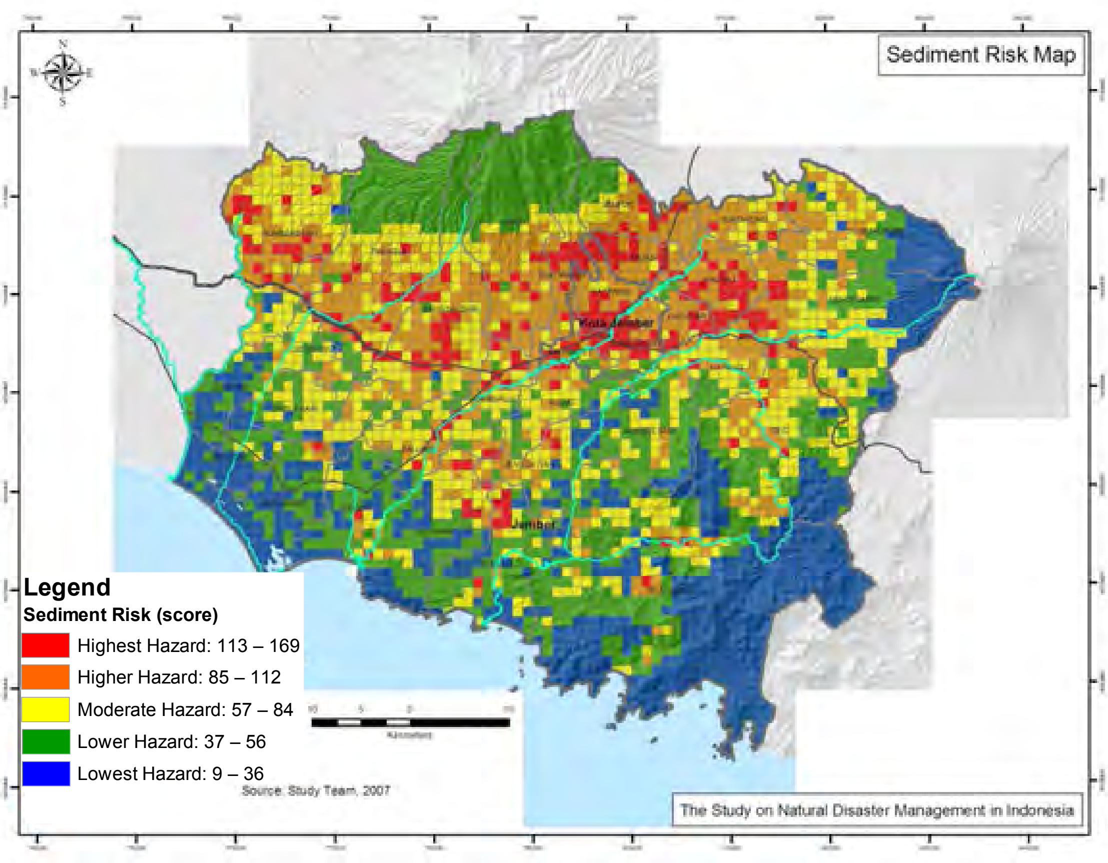


Figure 3.2.14 Sediment Risk Map for Kabupaten Jember

C. Possible Countermeasures against Sediment Disaster

Refer to the corresponding section of Kabupaten Jember for flood disaster. There are two areas selected which suffered seriously from sediment disaster (Refer to Figure 3.2.6). The one is located in the north, covering Kec. Panti, Kec. Sukorambi, Kec. Arjasa, Kec. Jelbuk, Kec. Patrang and Kec. Kaliwates (to be referred as "S1 Area"). The other is located in eastern mountainous region in Kec. Ledokombo and Kec. Silo (to be referred as "S2 Area").

Table 3.2.13 Possible Countermeasures for S1 Area and S2 Area

	Non-structural Countermeasure	Structural Countermeasure
S1 Area	・ Reforestation ・ Land use limitation ・ Early warning system for fast and appropriate evacuation ・ Community activities ・ Evacuation shelter and route	・ Guide bank (Spur dike) ・ Retaining wall ・ Slope protection works (Grating crib works)
S2 Area	・ Reforestation ・ Land use limitation ・ Early warning system for fast and appropriate evacuation ・ Community activities ・ Evacuation shelter and route	・ Groundsel works ・ Embankment ・ Revetment works ・ Hillside works (Forestation)

D. Activities for Capacity Development

Refer to the corresponding section of Kabupaten Jember for disaster, since all the workshops for water-related disasters (Flood and Sediment disasters) were held jointly.

2) Kabupaten Padang Pariaman

A. Hazard Map for Sediment Disaster

The hazard map for sediment disaster in Kabupaten Padang Pariaman was created based on data and information provided from the relevant organizations of Kabupaten Padang Pariaman and PSDA (Pengelolaan Sumber Daya Air) of West Sumatra Province through the discussions between the experts of the JICA study team and the counterpart members of Kabupaten Padang Pariaman. The indices used for creations of hazard map for sediment disaster are indicated in Table 3.2.15. The indices of "Slope", "Geology" and "Annual Rainfall" were adopted as indices of sediment hazard.

Table 3.2.14 Indices Used for Creations of Sediment Hazard Map

Hazard Indices	1) Slope (H_{P4}) 2) Geology (H_{P5}) 3) Annual Rainfall (H_{P6})

The formula used for assessment of sediment hazard for Kabupaten Padang Pariaman is shown below.

$$Hazard = H_{P4} + H_{P5} + H_{P6} \qquad \text{(Eq. 3.9)}$$

where, H_{P4}: Index value of slope, H_{P5}: Index value of geology and H_{P6}: Index value of annual rainfall.

Refer to Figure 3.2.15 showing the sediment hazard map for Kabupaten Padang Pariaman. As indicated in the figure, the values of sediment hazard were divided into five (5) classes indicating relative hazardous classification. Kabupaten Padang Pariaman is widely covered by friable pyroclastic products except the coastal plains in southwest region. In general, sediment hazard is higher in steep slope area combined with heavy rainfall. Based on the hazard assessment, almost 80% of the total area of Kabupaten Padang Pariaman can be regarded as the highest or high hazard areas in terms of sediment disaster. Particularly the north side of Kec.V Kamung Dalam, the north side of Kec.V Koto Timur, nearly the entire region of Kec.Palamuan and the west side of 2x11 Kayu Tanam are in the area of high hazard.

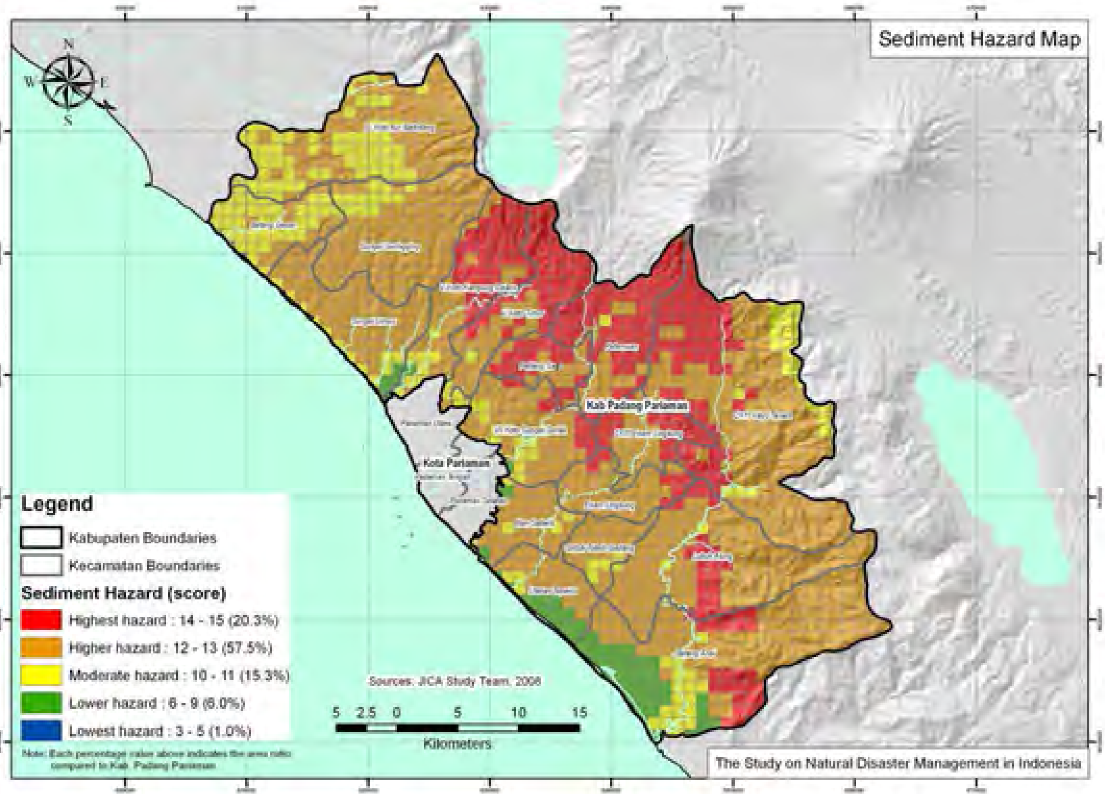


Figure 3.2.15 Sediment Hazard Map for Kabupaten Padang Pariaman

B. Risk Map for Sediment Disaster

The basics of creation of sediment risk map are described in section 3.2.1, CHAPTER 3. The vulnerability indices are shown in Table 3.2.15. The details of vulnerability indices for "Population Density (V_{P1})", "Built-up Area (V_{P2})" and "Road/Rail in Steep Area (V_{P4})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report.

Table 3.2.15 Vulnerability Indices Used for Sediment Disaster

Vulnerability Indices	1) Population Density (V_{P1}) 2) Built-up Area (V_{P2}) 3) Road/Rail in Steep Area (V_{P4})

The formula used for assessment of sediment risk for Kabupaten Padang Pariaman is shown below.

$$Risk = Hazard \times Vulnerability$$

$$Risk = (H_{P4} + H_{P5} + H_{P6}) \times (V_{P1} + V_{P2} + V_{P4}) \quad \text{(Eq. 3.10)}$$

where, H_{P4}: Index value of slope, H_{P5}: Index value of geology, H_{P6}: Index value of annual rainfall,V_{P1}: Index value of population density, V_{P2}: Index value of built-up area and V_{P4}: Index value of road/rail in steep area.

Refer to Figure 3.2.16 showing the sediment risk map for Kabupaten Padang Pariaman. The high risk grids are essentially in the area where buildings and population are concentrated. There were numbers of sediment disasters along road in steep slope in mountainous area or coastal terrace in the past. Even though the higher sediment hazards are indicated in the eastern region of Kabupaten Padang Pariaman, the risk indications in the region are not high since the vulnerability indices are not so high enough. Based on the risk assessment, almost 17% of the total area of Kabupaten Padang Pariaman can be regarded as the highest or high risk areas in terms of sediment disaster. Since the most of the area of Kabupaten Padang Pariaman are in high sediment hazard area, detailed survey and investigation are required prior to the implementation of land use plans.

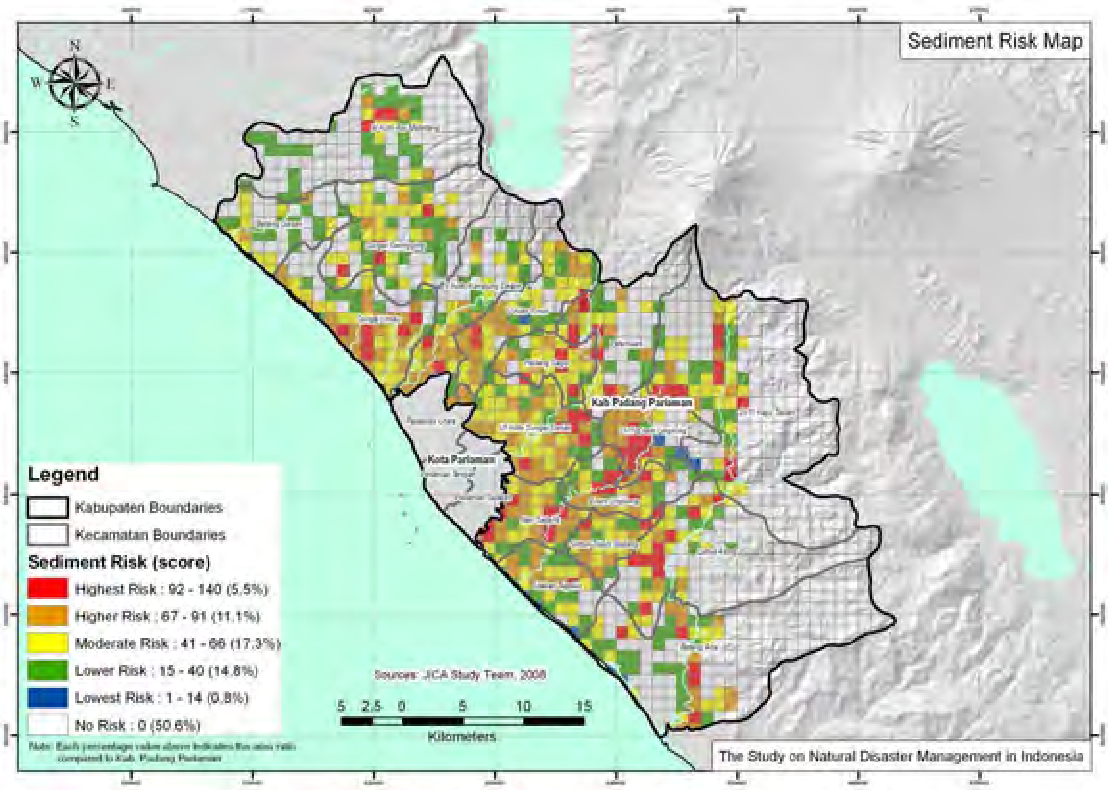


Figure 3.2.16 Sediment Risk Map for Kabupaten Padang Pariaman

C. Possible Countermeasures against Sediment Disaster

Countermeasures against sediment disaster are required in most all of the Kecamatans in Kabupaten Padang Pariaman. In particular, structural measures need to be constructed along certain trunk roads located on the north side of Kec. V Koto Kampung Dalam, the north side of Kec. V Koto Timur, the whole region of Kec. Patamuan, the west side of Kec. 2 x 11 Kayu Tanam, the central part of Kec. IV Koto Aur Malintang, *etc*. as soon as possible. It is important to conduct a detailed investigation and set priorities to proceed to the constructions. Furthermore, very steep slope exists behind some houses in the coastal side of Kec. Sungai Limau, where some structural measures need to be constructed. Table 3.2.16 shows the possible countermeasures for each Kecamatans of Kabupaten Padang Pariaman.

D. Activities for Capacity Development

Refer to the corresponding section of Kabupaten Padang Pariaman for flood disaster, since all the workshops for water-related disasters (Flood and Sediment disasters) were held jointly.

Table 3.2.16 Possible Countermeasures against Sediment Disaster

Kecamatan		Disaster Characteristics	Possible Countermeasures	
			Structural Countermeasures	Non-Structural Countermeasures
1	Batang Anai	Sediment disaster is hardly occured.	No necessity at present	No necessity at present
2	Lubuk Alung	There is collapse by the erosion of a river.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
3	Sintuk Toboh Gadang	Sediment disaster is hardly occured.	No necessity at present	No necessity at present
4	Ulakan Tapakis	Sediment disaster is hardly occured.	No necessity at present	No necessity at present
5	Nan Sebaris	Sediment disaster is hardly occured.	No necessity at present	No necessity at present
6	2 x 11 Enam Lingkung	Sediment disaster is hardly occured.	No necessity at present	No necessity at present
7	Enam Lingkung	There is collapse by the erosion of a river.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
8	2 x 11 Kayu Tanam	There is collapse by the erosion of a river.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works ･Concrete Spraying	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
9	VII Koto Sungai Sarik	Sediment disaster is hardly occured.	No necessity at present	No necessity at present
10	Patamuan	Many collapse places are seen at a road and river side.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
11	Padang Sago	Many large collapse places are located along a river.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
12	V Koto Kampung Dalam	A collapse place is located along a river.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
13	V Koto Timur	Many collapse places are seen at a road side.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
14	Sungai Limau	Collapse is seen in a marine terrace.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
15	Batang Gasan	There is collapse by the erosion of a river.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
16	Sungai Geringging	There is collapse with a comparatively large scale by the erosion of a river. Much collapse places are located also along a road.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)
17	IV Koto Aur Malintang	There is collapse with a comparatively large scale by the erosion of a river. Much collapse places are located also along a road.	･Retaining Wall ･Grating Crib Works ･Rockfall Prevention Works	･Land Use Limitation ･Prohibition of Cutting ･Early Warning(predictive information and rainfall gauging)

3) Kota Pariaman

A. Hazard Map for Sediment Disaster

The hazard map for sediment disaster in Kota Pariaman was created based on data and information provided from the relevant organizations of Kota Pariaman and PSDA (Pengelolaan Sumber Daya Air) of West Sumatra Province through the discussions between the experts of the JICA study team and the counterpart members of Kota Pariaman. The indices used for creations of hazard map for sediment disaster are indicated in Table 3.2.17. The indices of "Slope", "Geology" and "Annual Rainfall" were adopted as indices of sediment hazard.

Table 3.2.17 Indices Used for Creations of Sediment Hazard Map

Hazard Index	1) Slope (H_{P4}) 2) Geology (H_{P5}) 3) Annual Rainfall (H_{P6})

The formula used for assessment of sediment hazard for Kota Pariaman is shown below.

$$Hazard = H_{P4} + H_{P5} + H_{P6} \quad \text{(Eq. 3.11)}$$

where, H_{P4}: Index value of slope, H_{P5}: Index value of geology and H_{P6}: Index value of annual rainfall.

Refer to Figure 3.2.17 showing the sediment hazard map for Kota Pariaman. As indicated in the figure, the values of sediment hazard were divided into five (5) classes indicating relative hazardous classification. Similar to the geology of Kabupaten Padang Pariaman, pyroclastic products cover most of the area, especially the low relief hills on the north side of Kota Pariaman. The highest hazard can be seen in the north side of Kota Pariaman since the slope is also relatively steeper in the area. Lower hazard can be seen along the coastal line since the most of the area are very low and flat. The ratio of the highest and high hazard area to Kota Pariaman is more or less 60%.

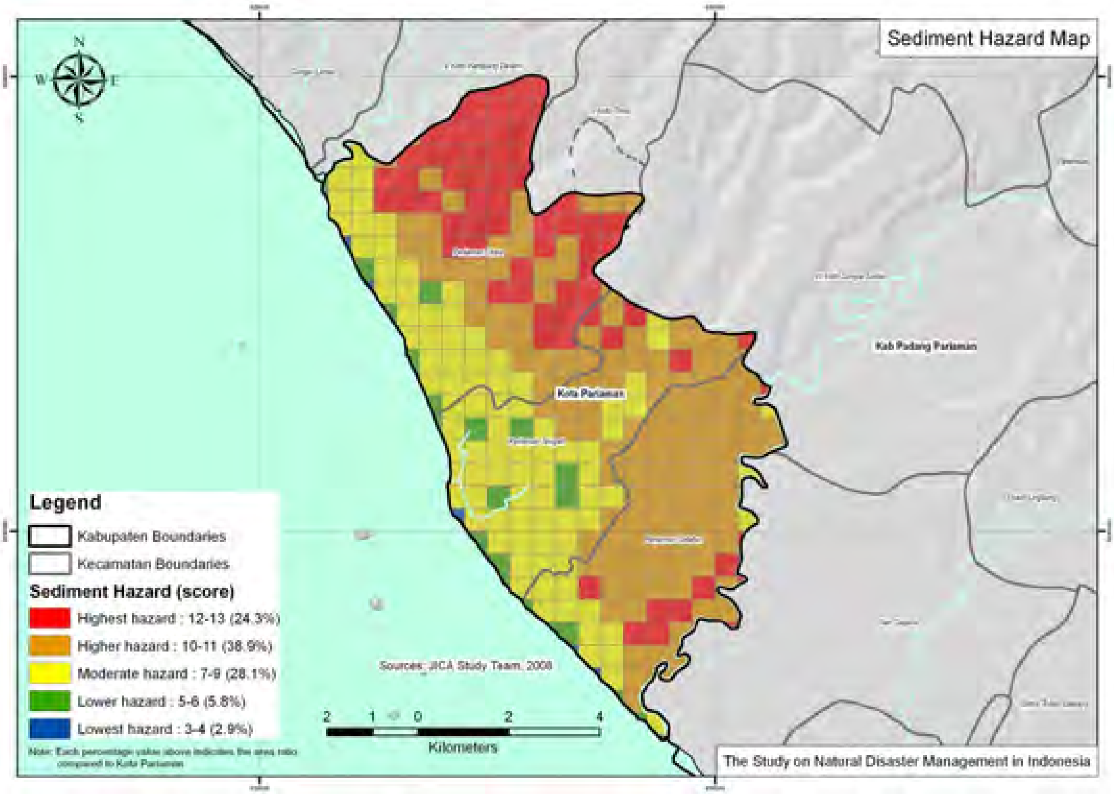


Figure 3.2.17 Sediment Hazard Map for Kota Pariaman

B. Risk Map for Sediment Disaster

The vulnerability indices are shown in Table 3.2.18. The details of vulnerability indices for "Population Density (V_{P1})", "Built-up Area (V_{P2})" and "Road/Rail in Steep Area (V_{P4})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report.

Table 3.2.18 Vulnerability Indices Used for Sediment Disaster

Vulnerability Indices	1) Population Density (V_{P1}) 2) Built-up Area (V_{P2}) 3) Road/Rail in Steep Area (V_{P4})

The formula used for assessment of sediment risk for Kota Pariaman is shown below.

$$Risk = Hazard \times Vulnerability$$

$$Risk = (H_{P4} + H_{P5} + H_{P6}) \times (V_{P1} + V_{P2} + V_{P4}) \qquad \text{(Eq. 3.12)}$$

where, H_{P4}: Index value of slope, H_{P5}: Index value of geology, H_{P6}: Index value of annual rainfall,V_{P1}: Index value of population density, V_{P2}: Index value of built-up area and V_{P4}: Index value of road/rail in steep area.

Refer to Figure 3.2.18 showing the sediment risk map for Kota Pariaman. Some 16% of Kota Pariaman are in the area of the highest risk. Overall trend covering Kota Pariaman shows that relatively higher scores were observed in the eastern part of Kota Pariaman. There are some river sections which have been apparently eroded by river flow with no revetment works along Mangau river. The potential risk is very high in such areas. However, there are hardly cliffs with steep slope except the highest risk areas, and the probability of sediment disaster is very low. However, it should be noted that public facilities in front of small sized cliffs need to be paid attention to in case of heavy rainfall.

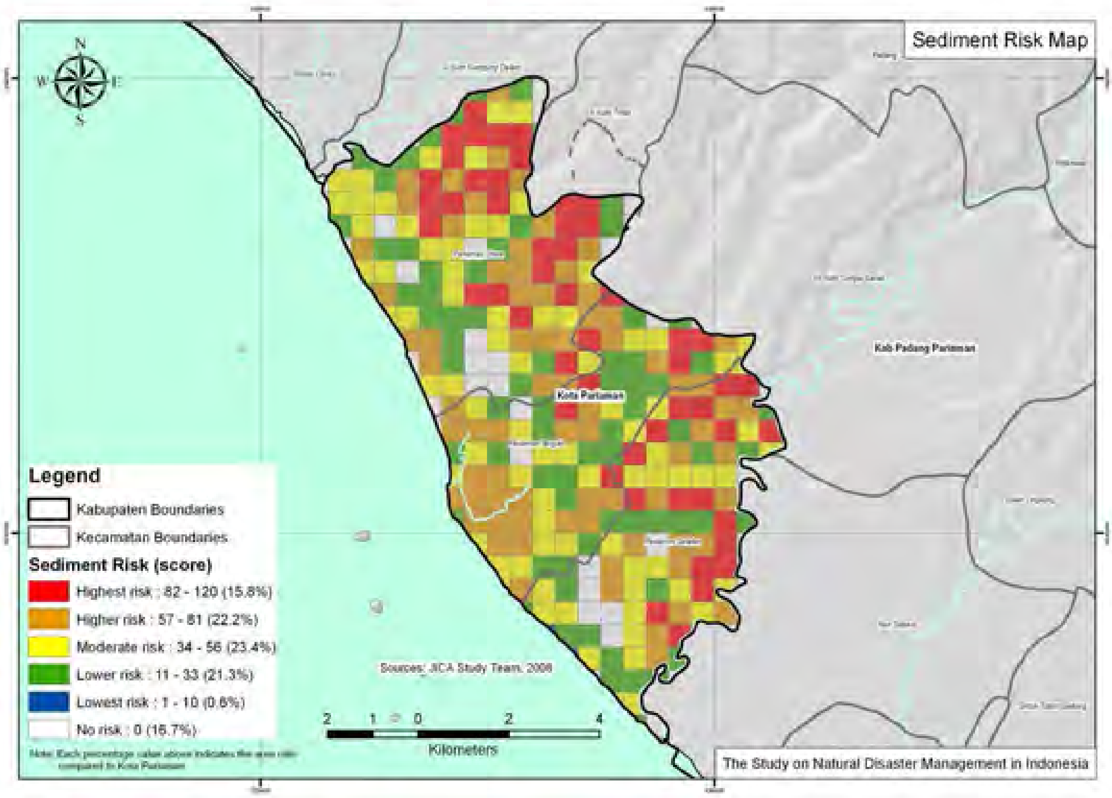


Figure 3.2.18 Sediment Risk Map for Kota Pariaman

C. Possible Countermeasures against Sediment Disaster

Since Kota Pariaman is located on comparatively flatland, it is not necessary to construct large scale structural countermeasure. In the eastern part of Kota Pariaman, there exists, however, some houses that have been built close to the small sized steep slope, which should be paid attention to. There are some river sections which have been apparently eroded by river flow with no revetment works along Mangau river. Thus, it is necessary to implement some structural countermeasures such as revetment works for the sections. Table 3.2.19 shows the possible countermeasures for each Kecamatans of Kota Pariaman.

Table 3.2.19 Possible Countermeasures against Sediment Disaster

Kecamatan		Disaster Characteristics	Possible Countermeasures	
			Structural Countermeasures	Non-Structural Countermeasures
1	North Pariaman Central Pariaman South Pariaman	There are few collapse places and there is little generating of sediment disaster. Although a collapse place is seen for a while on the north side of a city, there is no necessity for large-scale countermeasure.	・Retaining Wall	・Land Use Limitation ・Early Warning(predictive information and rainfall gauging)

D. Activities for Capacity Development

Refer to the corresponding section of Kabupaten Padang Pariaman for flood disaster, since all the workshops for water-related disasters (Flood and Sediment disasters) were held jointly.

3.2.4 Earthquake

This section describes the profile of hazard maps and risk (or damage) maps for the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman) regarding earthquake. And, the possible countermeasures against earthquake are listed for the pilot regions, respectively. The details are described in CHAPTER 3, Vol.3: Supporting Report.

1) Kabupaten Jember

A. Seismic Hazard Map

The meaning of the word “Hazard” is defined as the cause of disaster. Therefore, regarding earthquake, only the distribution of the ground surface acceleration intensity must be shown in “Hazard Map”. The expected value distribution of the ground surface acceleration intensity as seismic hazard map is shown in Figure 3.2.19. The ground surface acceleration intensity is described using PGA (Peak Ground Acceleralation) and MMI (Modified Mercalli Intensity scale). PGA is a value which will be obtained as the maximum value when the quake of the ground level is measured with accelerograph.

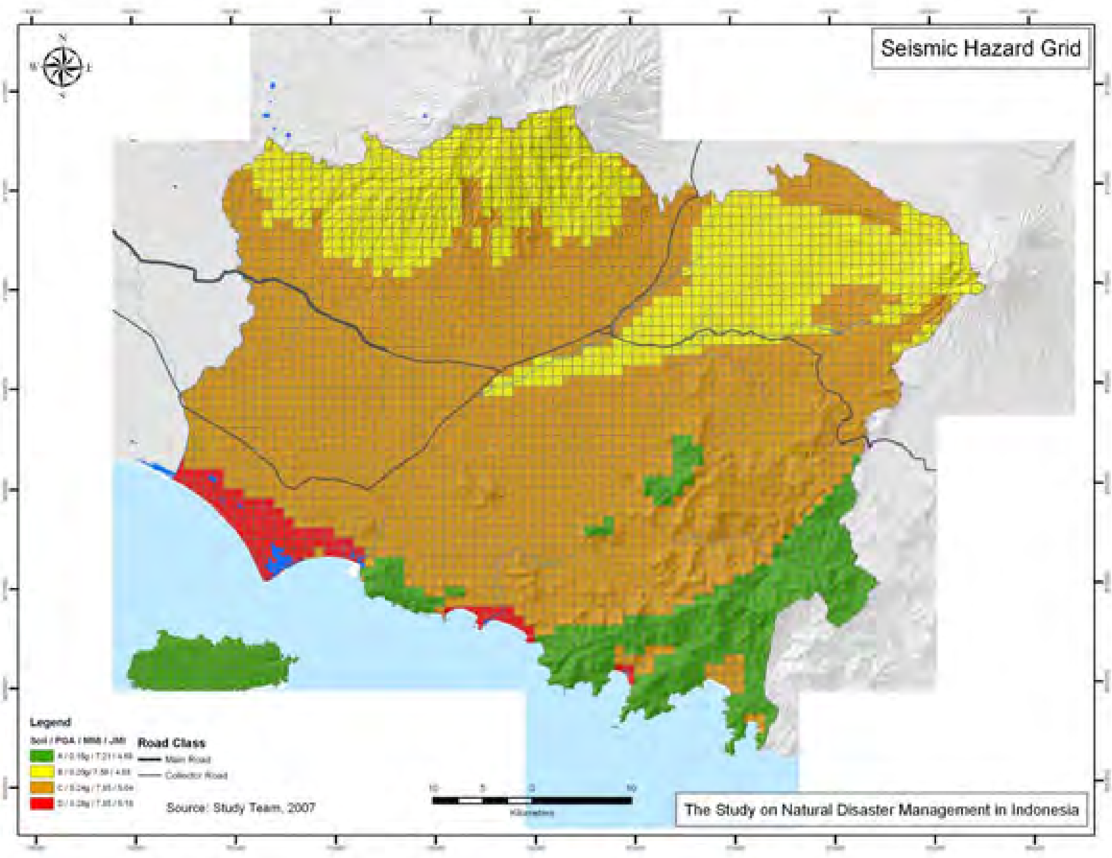


Figure 3.2.19 Seismic Hazard Map for Kabupaten Jember (Distribution of ground surface acceleration intensity)

The modified Mercalli intensity scale (MMI) divides earthquake intensity into 12 stages of evaluation, and each stage is defined by describing the incident through observation and sensing (for example; "Difficult to stand"). Therefore expression of MMI is discrete number originally but one digit below the decimal point is written in this report in order to distinguish a detailed difference. Estimated MMI for Kabupaten Jember is more or less 7.5. This level of intensity corresponds to almost "degree 5" in Japan Meteorological Agency Seismic Intensity Scale (it is called as JMI here in after). JMI also divides earthquake intensity into 10 stages of evaluation, and each stage is defined by describing the incident through observation and sensing. For instance, when the earthquake of "degree 5" in JMI occurs in Japan, some sort of slight damage can be found in some residential housing. If the same level of earthquake occurred in Indonesia including Kabupaten Jember, considerably serious damage are expected because earthquake resistant capacity of buildings in Kabupaten Jember is inferior to that of Japan.

B. Earthquake Risk Map

Figure 3.2.20 shows the ratio of expected number of damaged buildings as earthquake risk map at grid size of 1 × 1 km.

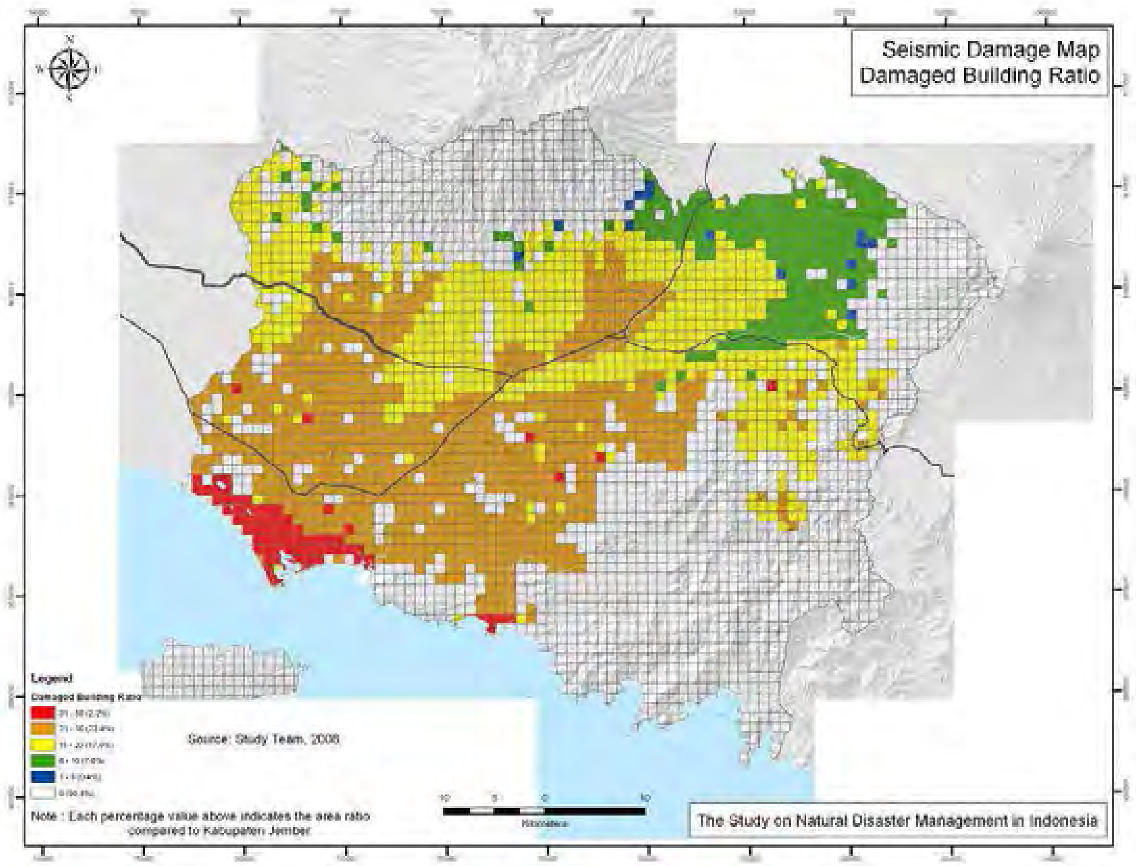


Figure 3.2.20 Earthquake Risk Map for Kabupaten Jember (Ratio of Damaged Buildings)

The intensity of surface ground acceleration depending on the location as indicated in Figure 3.2.19. The vulnerability of the buildings also differs depending on the building type. For instance, the reinforced concrete buildings, which were designed and constructed based on modern design thought, is sustainable with 10% or less of damage ratio even if the intensity of surface ground acceleration is equal to MMI 8. But, some unreinforced masonry buildings may suffer serious damages with almost 90% of damage ratio. There is some difficulty to wrap up earthquake risk into one map to draw down everything because of the above situation. In a word, earthquake risk is high at locations where vulnerable buildings exist.

C. Possible Countermeasures against Earthquake

In order to reduce the potential number of people killed due to earthquake, the most effective measure is strengthening of building structure as structural measure. It is extremely difficult to prepare effective warning system prior to earthquake disaster. Any effort done after earthquake can not be effective to reduce the potential number of lives lost. Rescue activity and supporting activity have to be done after earthquake occurrence but those efforts hardly save human life effectively. Possible structural measures are listed as follows:

- Consolidation of building permission and supervising system
- Establishment or improvement of diagnosis system for existing buildings
- Promotion for strengthening of existing buildings into earthquake resistant buildings
- Encouragement for rebuilding into earthquake resistant buildings
- Education in terms of earthquake resistant buildings

It is not possible to reduce potential number killed or injured by implementing non-structural measures, but it is still necessary to make some preparations for emergency rescue, life support and relief. The non-structural preparation activities are listed as follows:

- Securement of temporary shelters for evacuation
- Preparation and Stock necessary materials in case of emergency
- Mutual support agreement with the vicinity administrative organizations
- Cooperation with organizations of central government for disaster reduction
- Establishment of damage evaluation system in post-disaster phase
- Education and emergency drills for local community and residents at community level

2) Kabupaten Padang Pariaman

A. Seismic Hazard Map

The meaning of the word “Hazard” is defined as the cause of disaster. Therefore, regarding earthquake, only the distribution of the ground surface acceleration intensity must be shown in “Hazard Map”. The expected value distribution of the ground surface acceleration intensity as seismic hazard map is shown in Figure 3.2.21. The ground surface acceleration intensity is described using PGA (Peak Ground Acceleralation) and MMI (Modified Mercalli Intensity scale). PGA is a value which will be obtained as the maximum value when the quake of the ground level is measured with accelerograph.

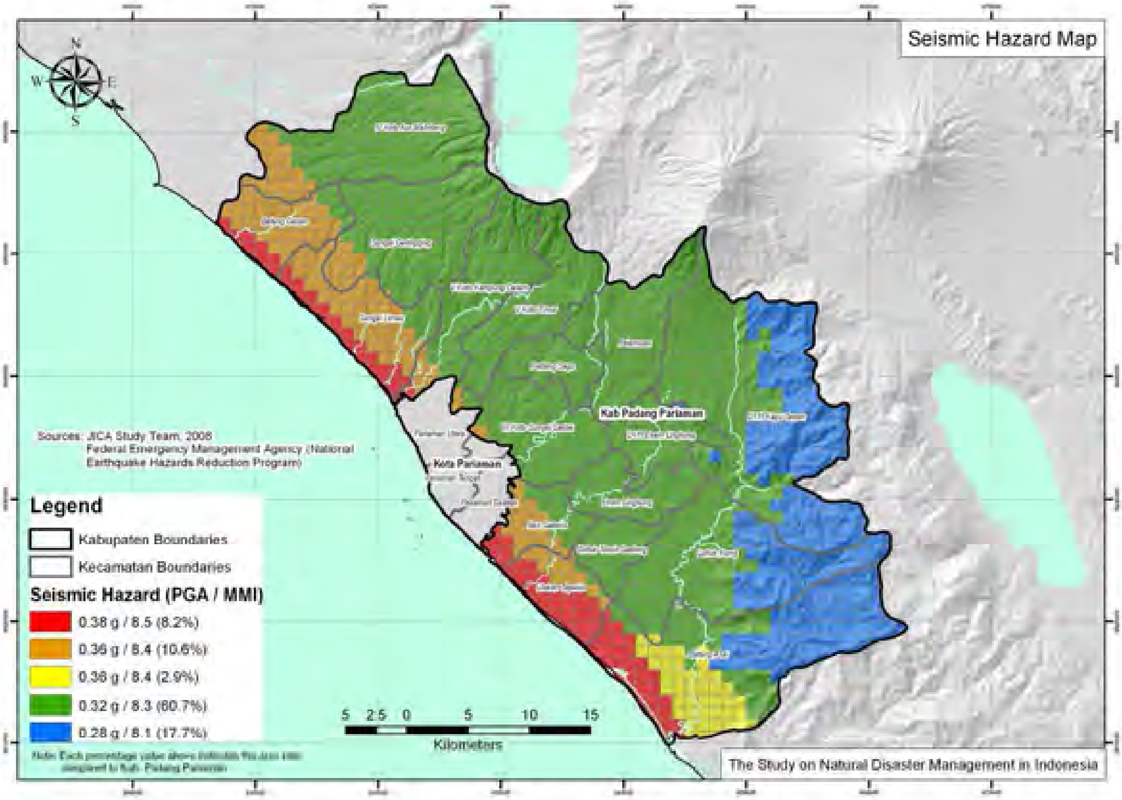


Figure 3.2.21 Seismic Hazard Map for Kabupaten Padang Pariaman (Distribution of ground surface acceleration intensity)

The modified Mercalli intensity scale (MMI) divides earthquake intensity into 12 stages of evaluation, and each stage is defined by describing the incident through observation and sensing (for example; “Difficult to stand”). Therefore expression of MMI was a discrete number originally, but one digit after the decimal point is written in this report in order to distinguish a detailed difference. Estimated MMI values for Kabupaten Padang Pariaman cover from 8.1 to 8.5. This level of intensity corresponds to almost “degree 5 or more” in JMI. JMI also divides earthquake intensity into 10 stages of evaluation, and each stage is defined by describing the incident through observation and sensing. For instance, when the earthquake of "degree 5 or more" in JMI occurs in Japan, some sort of slight damage can be found in some residential housing. If the same level of earthquake occurred in Indonesia including Kabupaten Padang Pariaman, considerably serious damages are expected because earthquake resistant capacity of buildings in Kabupaten Padang Pariaman is inferior to that of Japan.

B. Earthquake Risk Map

Figure 3.2.22 shows the expected number of damaged buildings as earthquake risk map at grid size of 1 × 1 km. The intensity of surface ground acceleration differs depending on the location as indicated in Figure 3.2.21. The vulnerability of the buildings also differs depending on the building type. For instance, the reinforced concrete buildings, which were designed and constructed based on modern design thought, is sustainable with 10% or less of damage ratio even if the intensity of surface ground motion is equal to MMI 8. But, some unreinforced masonry buildings may suffer serious damages with almost 90% of damage ratio. There is some difficulty to wrap up earthquake risk into a map to draw down everything because of the above situation. In a word, earthquake risk is high at locations where vulnerable buildings exist.

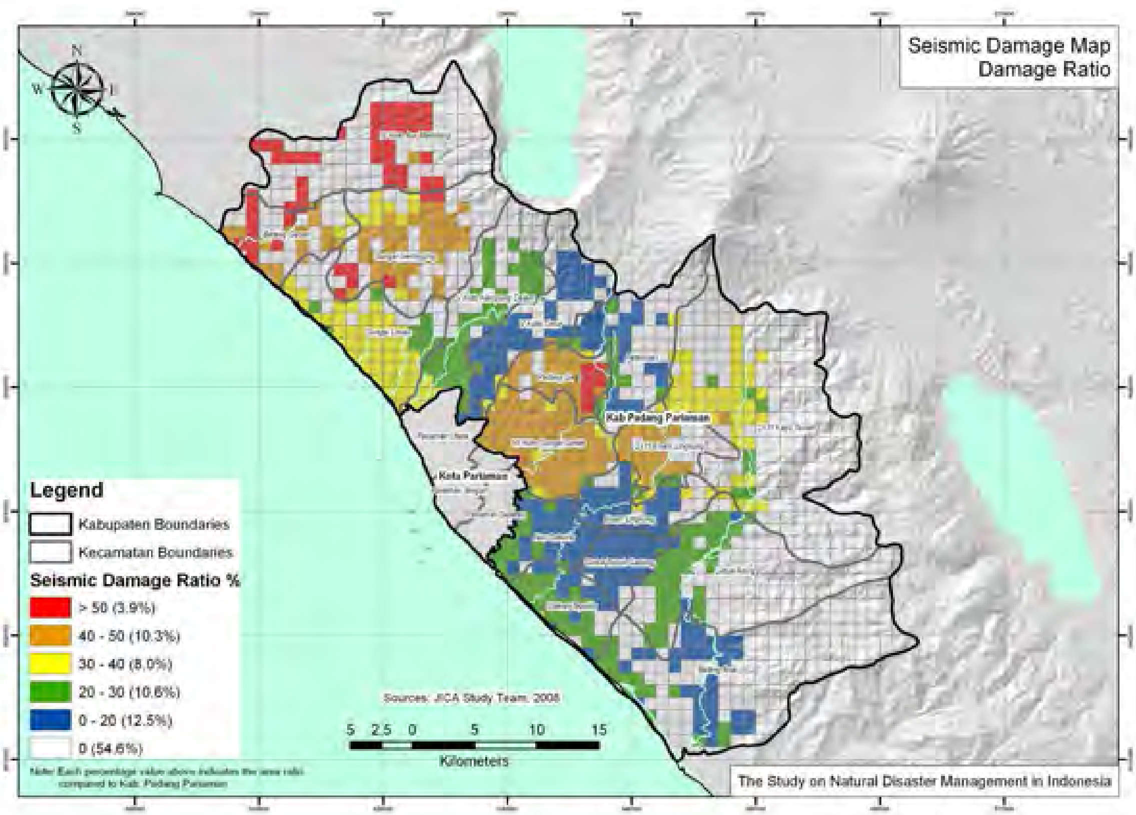


Figure 3.2.22 Earthquake Risk Map for Kabupaten Padang Pariaman (Ratio of Damaged Buildings)

C. Possible Countermeasures against Earthquake

Refer to the corresponding section of Kabupaten Jember, since all the possible countermeasures are the same for all of the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman).

3) Kota Pariaman

A. Seismic Hazard Map

The meaning of the word "Hazard" is defined as the cause of disaster. Therefore, regarding earthquake, only the distribution of the ground surface acceleration intensity must be shown in "Hazard Map". The expected value distribution of the ground surface acceleration intensity as seismic hazard map is shown in Figure 3.2.21. The ground surface acceleration intensity is described using PGA (Peak Ground Acceleralation) and MMI (Modified Mercalli Intensity scale). PGA is a value which will be obtained as the maximum value when the quake of the ground level is measured with accelerograph.

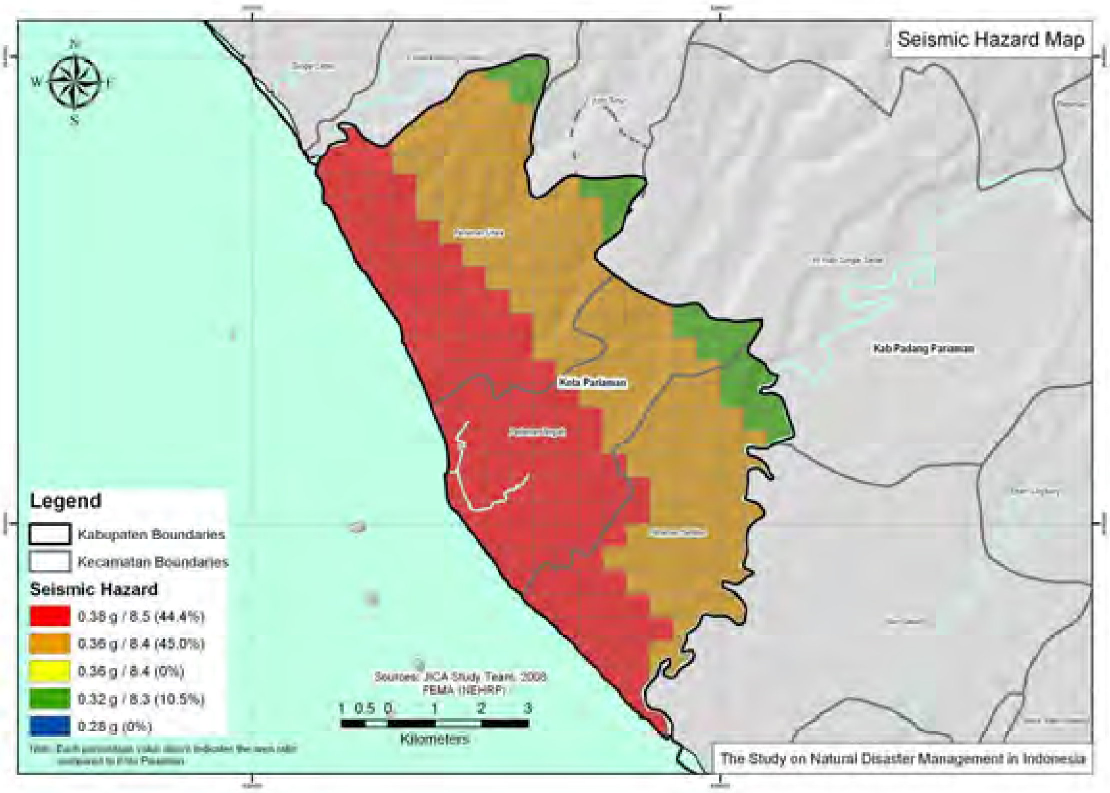


Figure 3.2.23 Seismic Hazard Map for Kota Pariaman (Distribution of ground surface acceleration intensity)

The modified Mercalli intensity scale (MMI) divides earthquake intensity into 12 stages of evaluation, and each stage is defined by describing the incident through observation and sensing (for example; "Difficult to stand"). Therefore expression of MMI is discrete number originally but one digit below the decimal point is written in this report in order to distinguish a detailed difference. Estimated MMI values for Kota Pariaman cover from 8.1 to 8.5. This level of intensity corresponds to almost "degree 5 or more" in JMI. JMI also divides earthquake intensity into 10 stages of evaluation, and each stage is defined by describing the incident through observation and sensing. For instance, when the earthquake of "degree 5 or more" in JMI occurs in Japan, some sort of slight damage can be found in some residential housing. If the same level of earthquake occurred in Indonesia including Kota Pariaman, considerably serious damages are expected because earthquake resistant capacity of buildings in Kota Pariaman is inferior to that of Japan.

B. Earthquake Risk Map

Figure 3.2.24 shows the expected number of damaged buildings as earthquake risk map at grid size of 500 × 500 m. The intensity of surface ground motion differs depending on the location as indicated in Figure 3.2.23. The vulnerability of the buildings also differs depending on the building type. For instance, the reinforced concrete buildings, which were designed and constructed based on modern design thought, is sustainable with 10% or less of damage ratio even if the intensity of surface ground motion is equal to MMI 8. But, some unreinforced masonry buildings may suffer serious damages with almost 90% of damage ratio. There is some difficulty to wrap up earthquake risk into a map to draw down everything because of the above situation. In a word, earthquake risk is high at locations where vulnerable buildings exist.

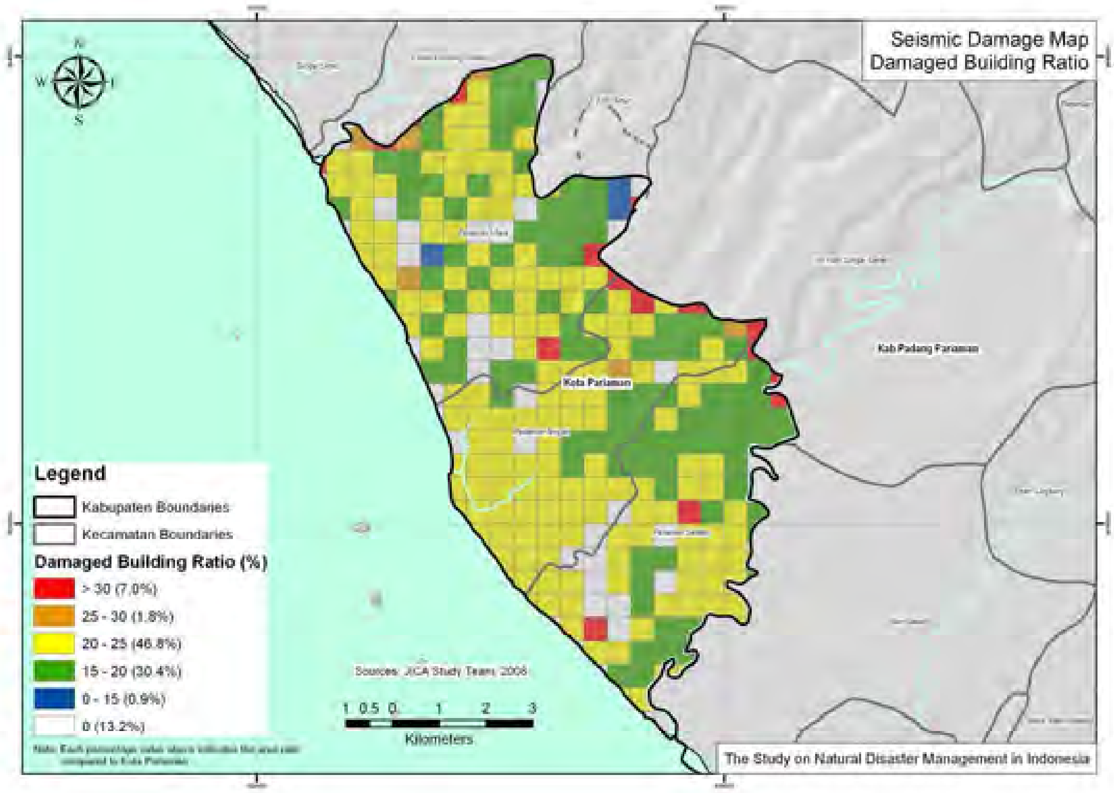


Figure 3.2.24 Earthquake Risk Map for Kota Pariaman (Ratio of Damaged Buildings)

C. Possible Countermeasures against Earthquake

Refer to the corresponding section of Kabupaten Jember, since all the possible countermeasures are the same for all of the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman).

3.2.5 Tsunami disaster

This section describes the profile of hazard maps and risk (or damage) maps for the pilot regions (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman) regarding tsunami disaster. Also, the possible countermeasures against tsunami disaster are listed for the pilot regions. The details are described in CHAPTER 4, Vol.3: Supporting Report.

1) Kabupaten Jember

A. Tsunami Hazard Map

There are various methods to assess inundation area and depth due to tsunami, for example numerical simulation method, method based on historical inundation records, *etc*. In this study, three candidate layers were obtained as the hazard map for tsunami disaster in Kabupaten Jember. And, the layer, in which inundation and depth were estimated based on ground elevation, were selected as the hazard map for tsunami disaster, which gives the result on the most dangerous side and is comparatively easy to formulate.

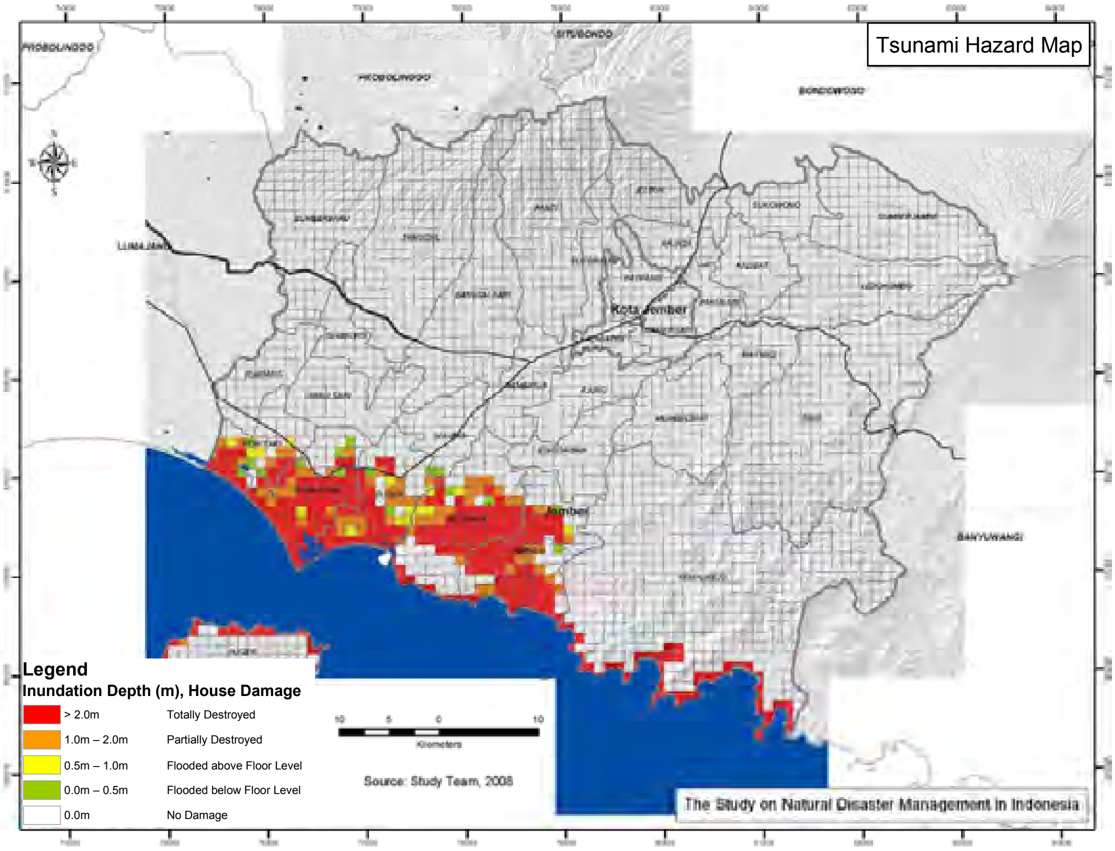


Figure 3.2.25 Tsunami Hazard Map for Kabupaten Jember

The maximum run-up height of the East Java tsunami (1994) was 8 m or less. Therefore, 8 m above sea level was set to standard height of the expected tsunami run-up. Figure 3.2.25 indicates that the tsunami hazard has concentrated in low-lying area near the coast. And the expected tsunami flood area has extended from the coast to inland widely in accordance with the vast low-lying area which is one of the geographical features of Kabupaten Jember.

B. Tsunami Risk Map

The indices used for the creations of tsunami hazard map and risk map are shown in Table 3.2.20. The details of vulnerability indices for "Population Density (V_{J1})", "Built-up Area (V_{J2})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report. The vulnerability index of "Damage Rate (V_{J3})" is explained in CHAPTER 4, Vol.3: Supporting Report.

Table 3.2.20 Indices Used for the Creations of Tsunami Hazard Map and Risk Map

Hazard Index	Inundation area and depth estimated based on ground elevation (H_{J3})
Vulnerability Indices	1) Population Density (V_{J1}) 2) Built-up Area (V_{J2}) 3) Damage Rate (V_{J3})

The formula used for assessment of tsunami risk for Kabupaten Jember is shown below.

Risk = Hazard x Vulnerability

$$Risk = H_{J3} \times V_{J3} \times (V_{J1} + V_{J2}) \qquad \text{(Eq. 3.13)}$$

where H_{J3}: Index value of tsunami hazard, V_{J1}: Index value of population density, V_{J2}: Index value of built-up area and V_{J3}: Index value of damage rate.

Figure 3.2.26 indicates that the tsunami risk has concentrated on the villages in the low-lying area near the coast and river mouse such as Kec. Puger, Kec. Getem, and Kec. Watuulo of the west-center coast. In eastern area, the village which has risk for tsunami hazard is only Bandialit located in head of bay. These villages in low-lying area near river mouse have usually fishery port or slipways for fishing boat. Thus the risk of fishery damage is very high in addition to the risk of house and human damage.

C. Possible Countermeasures against Tsunami Disaster

The basis to evade tsunami disaster is to evacuate from the area of high hazard or risk. Evacuation to higher place, which is one of the most effective means, is highly recommendable. However, it is often difficult to obtain consent of the residents such as fishermen because a tsunami disaster doesn't occur frequently. Therefore, it is necessary to consider comprehensive measures including the reinforcement of houses against the waves, evacuation, *etc.* in order to reduce the extent of tsunami disaster. Possible countermeasures against tsunami and their applicability to Kabupaten Jember are listed in Table 3.2.21.

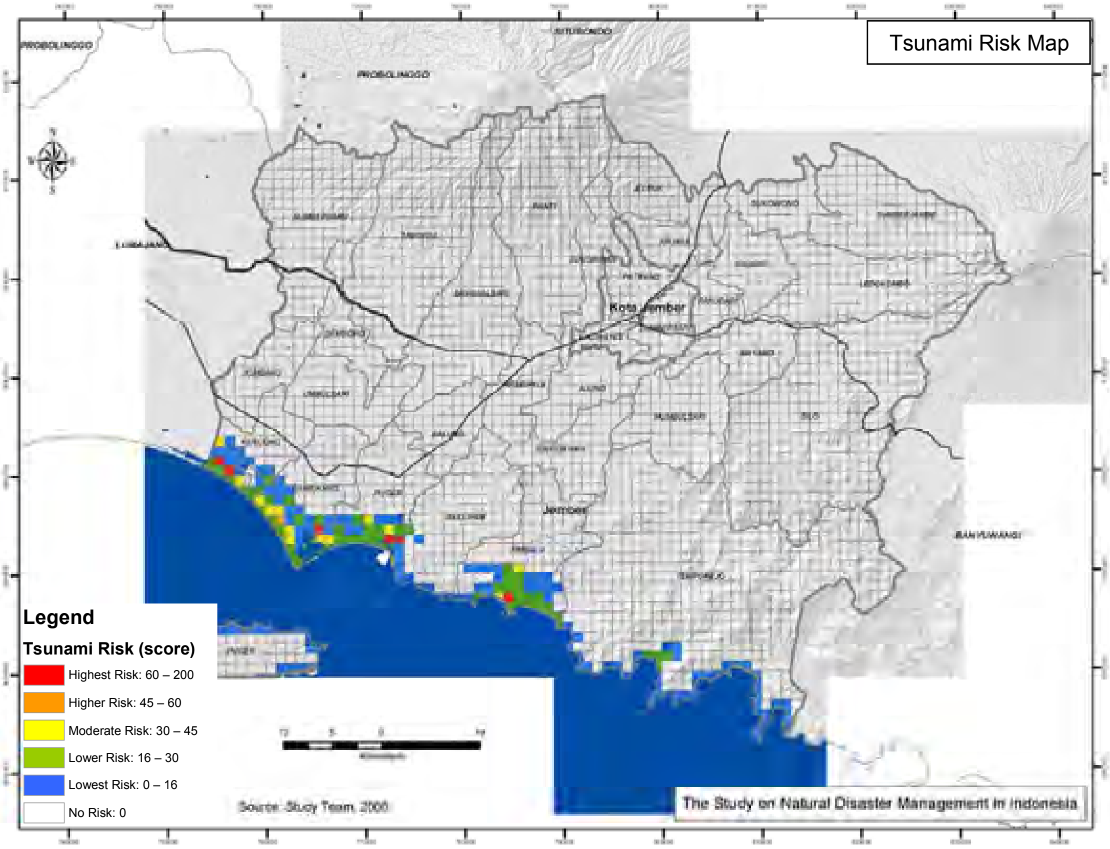


Figure 3.2.26 Tsunami Risk Map for Kabupaten Jember

Table 3.2.21 List of Possible Countermeasures against Tsunami Disaster for Kabupaten Jember

- Structural Countermeasures
  - Tide embankment, Tsunami breakwater, Tsunami floodgate, and River embankment
  - Coastal forest
  - Wave-proof building
- City planning for tsunami disaster prevention
  - Relocation
  - Land Use Regulation
- Tsunami hazard mapping
- Maintenance of evacuation site and route
- Tsunami drills
- Education

D. Activities for Capacity Development

The hazard map and risk map in terms of tsunami disaster were basically formulated with counterpart members so that technology transfer can be done smoothly. The activities during the workshops to formulate the hazard and risk maps were helpful to develop the capacity of counterpart members. The activities for capacity development are shown in 3.2.22.

Table 3.2.22 List of Workshop in Terms of Tsunami Disaster for Kabupaten Jember

Date	Time	Location	Participants (CP)	Participants (Study Team)	Agenda
June 26, 2007	10:00-16:00	Desa Sumberejo (Payangan)	PU Officer	Nagasawa, Watanabe	• Joint Survey with C/P
June 27, 2007	10:00-16:00	Desa Andongerejo (Bandi alit)	PU Officer	Nagasawa, Watanabe	• Joint Survey with C/P
July 9, 2007	10:00-16:00	Desa Mayangan Desa Majomulyo (Getem)	PU Officer Officer and staff of Kantol Kecamatan Gumukmas	Nagasawa	• Joint Survey with C/P
July 18, 2007	10:00-12:00	JICA Study Office in Kab. Jember	PU Officer Officer and staff of Kantol Kecamatan Gumukmas	Tsukamoto, Nagasawa, Watanabe	• Workshop about Tsunami HM

2) Kabupaten Padang Pariaman

A. Tsunami Hazard Map

There are various methods to predict inundation area and depth due to tsunami, for example numerical simulation method, method based on historical inundation records, *etc*. In this study, three candidate layers were obtained as the hazard map for tsunami disaster in Kabupaten Padang Pariaman. And, the layer, in which inundation and depth were estimated based on ground elevation, were selected as the hazard map for tsunami disaster, which gives the result on the most dangerous side and is comparatively easy to formulate.

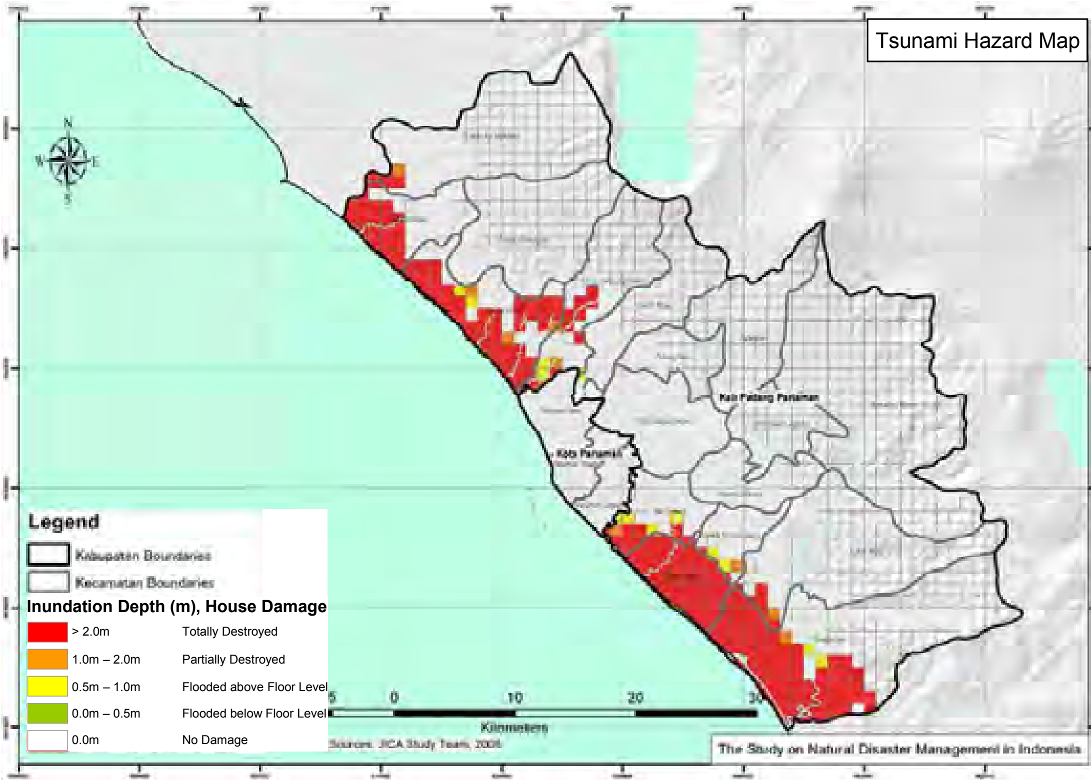


Figure 3.2.27 Tsunami Hazard Map for Kabupaten Padang Pariaman

Figure 3.2.27 indicates that the tsunami hazard has concentrated on low-lying area near the coast. The low-lying area of the northwest of Kabupaten Padang Pariaman is comparatively narrow and 1-3km in width because the plateau is close to the coast as a geomorphic characteristic. In contrast, the southern part near the coast is a vast low-lying area which has extended 5-7km from the coast to inland. Accordingly, the tsunami hazard area has extended deeply to inland.

B. Tsunami Risk Map

The indices used for the creations of tsunami hazard map and risk map are shown in Table 3.2.23.

The details of vulnerability indices for "Population Density (V_{P1})", "Built-up Area (V_{P2})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report. The vulnerability index of "Damage Rate (V_{P5})" is explained in CHAPTER 4, Vol.3: Supporting Report.

Table 3.2.23 Indices Used for the Creations of Tsunami Hazard Map and Risk Map

Hazard Index	Inundation area and depth estimated based on ground elevation (H_{P3})
Vulnerability Indices	1) Population Density (V_{P1}) 2) Built-up Area (V_{P2}) 3) Damage Rate (V_{P3})

The formula used for assessment of tsunami risk for Kabupaten Padang Pariaman is shown below.

Risk = Hazard x Vulnerability

$$Risk = H_{P3} \times V_{P3} \times (V_{P1} + V_{P2}) \quad \text{(Eq. 3.14)}$$

where H_{P3}: Index value of tsunami hazard, V_{P1}: Index value of population density, V_{P2}: Index value of built-up area and V_{P3}: Index value of damage rate.

Figure 3.2.28 indicates that the tsunami risk has spread out all parts of coastal area of Kabupaten Padang Pariaman. Especially, the damage risk of Pasir Baru, Pilubang and Pasar Sungai Limau in Kechamatan Sungai Limau on which the population and the residential area concentrate is very high. In Kechamatan Batang Gasan which is northern area of Kabupaten Padang Pariaman, the area with high risk is limited to a part of coastal area. In southern area, Ulakan of Kechamatan Ulakan Tapakis has high risk for flood due to tsunami. Meanwhile, the risk of the south low-lying area in Kechamatan Batang Anai is low except the residential area of Kataping. Though the house damage and human damage seem to be low in southern area, the actual risk of tsunami hazard is very high because Minangkabau International Airport is located there. The above-mentioned areas are located near the coast and often have fishery port or slipways for fishing boat. Thus the risk of fishery damage is very high. Additionally, even in the inland which is far from the coastline, it is necessary to pay attention to the low-lying area along the river that the tsunami goes into easily.

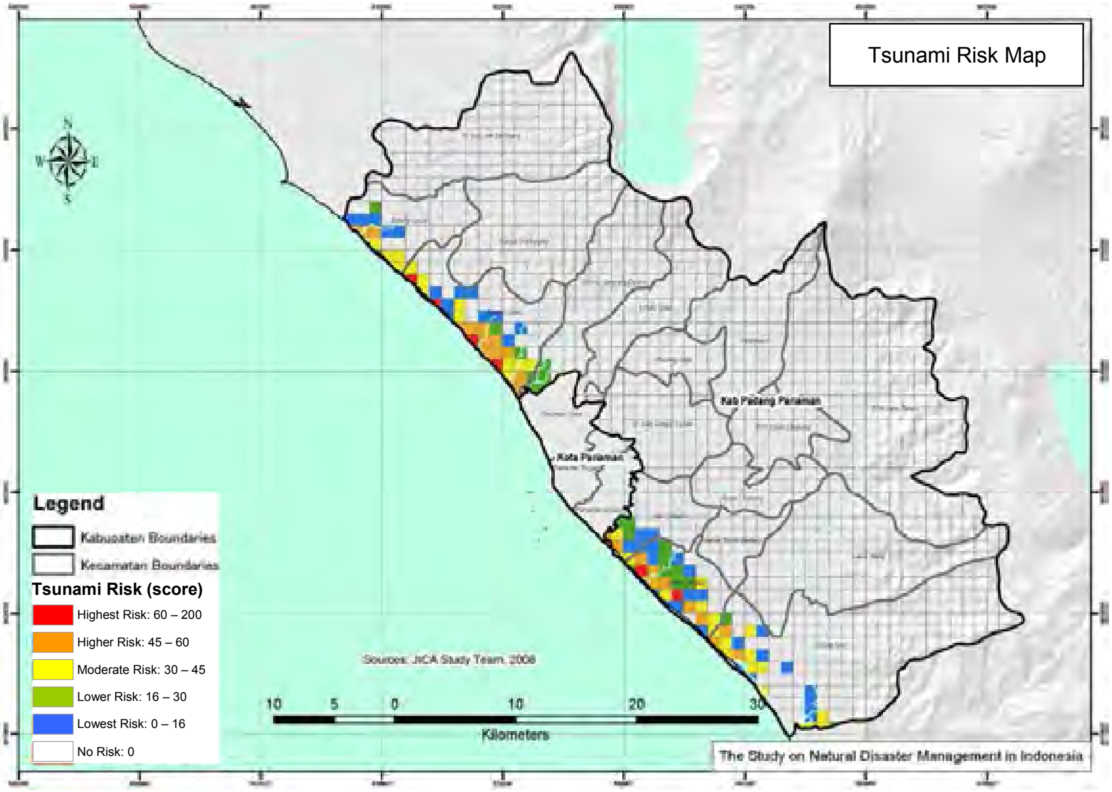


Figure 3.2.28 Tsunami Risk Map for Kabupaten Padang Pariaman

C. Possible Countermeasures against Tsunami Disaster

Possible countermeasures against tsunami for Kecamatans of Kabupaten Padang Pariaman in hazard or risk of tsunami disaster are listed in Table 3.2.24. The countermeasures were classified into two: 1) Short-term Countermeasures and 2) Long-term Countermeasures.

D. Activities for Capacity Development

The hazard map and risk map in terms of tsunami disaster were basically formulated with counterpart members so that technology transfer can be done smoothly. The activities during the workshops to formulate the hazard and risk maps were helpful to develop the capacity of counterpart members. The activities for capacity development are shown in Table 3.2.25.

Table 3.2.24 List of Possible Countermeasures against Tsunami Disaster

Kecamatan (Oceanfront Kecamatan)		Existing Condition					Possible Countermeasures	
		Past Coastal Disaster (rising tide)	Evacuation places or high places in 2km from the coast	Coastal Forest in front of settlement	Possibility of relocation	Population Density in the coastal area	Structural Countermeasures	Non-Structural Countermeasures
1	Batang Anai	No	No	Yes, but thin (Northern Area) No Southern Area)	Low Adequate relocation site is very far.	Comparatively Low	Short-term Countermeasure - Wave-proof building - Maintenance of Evacuation site and Route - Construction and Designation of adequate building as Tsunami shelter - Installation of Evacuation sign board Long-term Countermeasure -	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System
4	Ulakan Tapakis	Yes. Serious	No	Yes but thin	Low Adequate relocation site is very far.	Comparatively Low Partly High (Ulakan)	Short-term Countermeasure - Wave-proof building - Maintenance of Evacuation site and Route - Construction and Designation of adequate building as Tsunami shelter - Installation of Evacuation sign board Long-term Countermeasure - Tide embankment, River embankment (partly)	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System
5	Nan Sabaris	No	No	Yes but thin	Low Adequate relocation site is very far.	Comparatively Low	Short-term Countermeasure - Wave-proof building - Maintenance of Evacuation site and Route - Construction and Designation of adequate building as Tsunami shelter - Installation of Evacuation sign board Long-term Countermeasure - Tide embankment, River embankment (partly)	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System
14	Sungai Limau	Yes. Serious	Yes (Northern Area) No (PasirBaru, Pilubang)	Yes but thin	High (Except Southern Area)	Comparatively Low Partly High (Paser Sungai Limau, Pasir Baru, Pilubang)	Short term Countermeasure - Wave-proof building - Maintenance of Evacuation site, Route - Construction and Designation of adequate building as Tsunami shelter (PasirBaru, Pilubang) - Installation of Evacuation sign board Long term Countermeasure - Tide embankment, River embankment (partly)	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System It was already installed partly in southside of Batang Naras
15	Batang Gasan	Yes. Serious	Yes	Yes but thin	High	Comparatively Low	Short term Countermeasure - Wave-proof building - Maintenance of Evacuation site and Route - Installation of Evacuation sign board Long term Countermeasure	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System

Table 3.2.25 List of Workshops in terms of Tsunami Disaster for Kabupaten Padang Pariaman and Kota Pariaman

Date	Time	Location	Participants (CP)	Participants (Study Team)	Agenda
June 19, 2008	13:00-15:00	JICA Study Office in Pariaman city	C/P Disaster Countermeasures Team	Kato, Hayashi, Fujisawa, Nagasawa, Watanabe	[Workshop] ・ Introduction of Tsunami Management in Japan
July 3, 2008	7:00-17:00	JICA Study Office in Pariaman city Field Survey	C/P Disaster Countermeasures Team	Kato, Hayashi, Fujisawa, Nagasawa, Watanabe	[Field Trip] ・ Briefing ・ Discussion on physical characteristics of each disaster in the field
July 10, 2008	10:00-17:00	Pasir baru Pilubang Ulakan Tapakis river Anai river	Kota Pariaman PU Mr. Nopriyadi Sukri	Kato, Nagasawa	・ Joint Survey with C/P ・ Elevation Survey
July 16, 2008	10:00-17:00	Pasir baru Pilubang Tiram	Kab. PD. Pariaman Mr. Ir. Abd. Halim, Mr. Si	Nagasawa	・ Joint Survey with C/P ・ Actual condition and future plan of Countermeasures against Tsunami
July 25, 2008	10:00-12:00	JICA Study Office in Pariaman city	C/P Disaster Countermeasures Team	Nagasawa	[Workshop] Formulation of Tsunami Hazard Map

3) Kota Pariaman

A. Tsunami Hazard Map

There are various methods to predict inundation area and depth due to tsunami, for example numerical simulation method, method based on historical inundation records, *etc*. In this study, three candidate layers were obtained as the hazard map for tsunami disaster in Kota Pariaman. And, the layer, in which inundation and depth were estimated based on ground elevation, were selected as the hazard map for tsunami disaster, which gives the result on the most dangerous side and is comparatively easy to formulate.

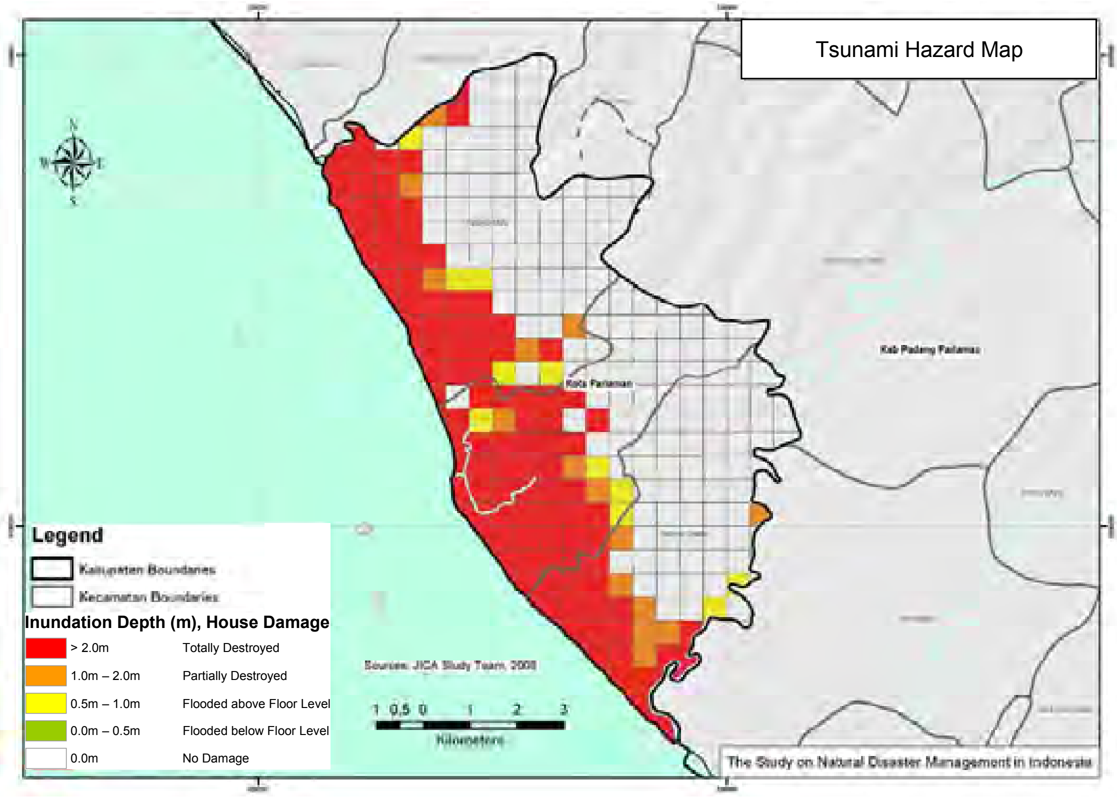


Figure 3.2.29 Tsunami Hazard Map for Kota Pariaman

Figure 3.2.29 indicates that the tsunami hazard has concentrated on low-lying area near the coast. And the expected tsunami flood area has extended from the coast to inland widely in accordance with the vast low-lying area which extend about 2-3 km from the coast to the inland in Kota Pariaman.

B. Tsunami Risk Map

The indices used for the creations of tsunami hazard map and risk map are shown in Table 3.2.26. The details of vulnerability indices for "Population Density (V_{P1})", "Built-up Area (V_{P2})" are described in section of 1.6.4, CHAPTER 1, Vol.3: Supporting Report. The vulnerability index of "Damage Rate (V_{P3})" is explained in CHAPTER 4, Vol.3: Supporting Report.

Table 3.2.26 Indices Used for the Creations of Tsunami Hazard Map and Risk Map

Hazard Index	Inundation area and depth estimated based on ground elevation (H_{P3})
Vulnerability Indices	1) Population Density (V_{P1}) 2) Built-up Area (V_{P2}) 3) Damage Rate (V_{P3})

The formula used for assessment of tsunami risk for Kota Pariaman is shown below.

Risk = Hazard x Vulnerability

$$\text{Risk} = H_{P3} \times V_{P3} \times (V_{P1} + V_{P2}) \qquad \text{(Eq. 3.15)}$$

where H_{P3}: Index value of tsunami hazard, V_{P1}: Index value of population density, V_{P2}: Index value of built-up area and V_{P3}: Index value of damage rate.

Figure 3.2.30 indicates that the tsunami risk has spread out all parts of coastal area in 1-2 km width. Especially, the damage risk of Central Pariaman on which the population and the residential area concentrate is very high. Additionally, Central Pariaman has a lot of important installations, which are government buildings such as City Hall, transportation facilities such as railways, roads and bridges, port facilities, fishery port facilities, in the range only 1 km from the coastline, Thus the damage risk of infrastructure is very serious in Central Pariaman.

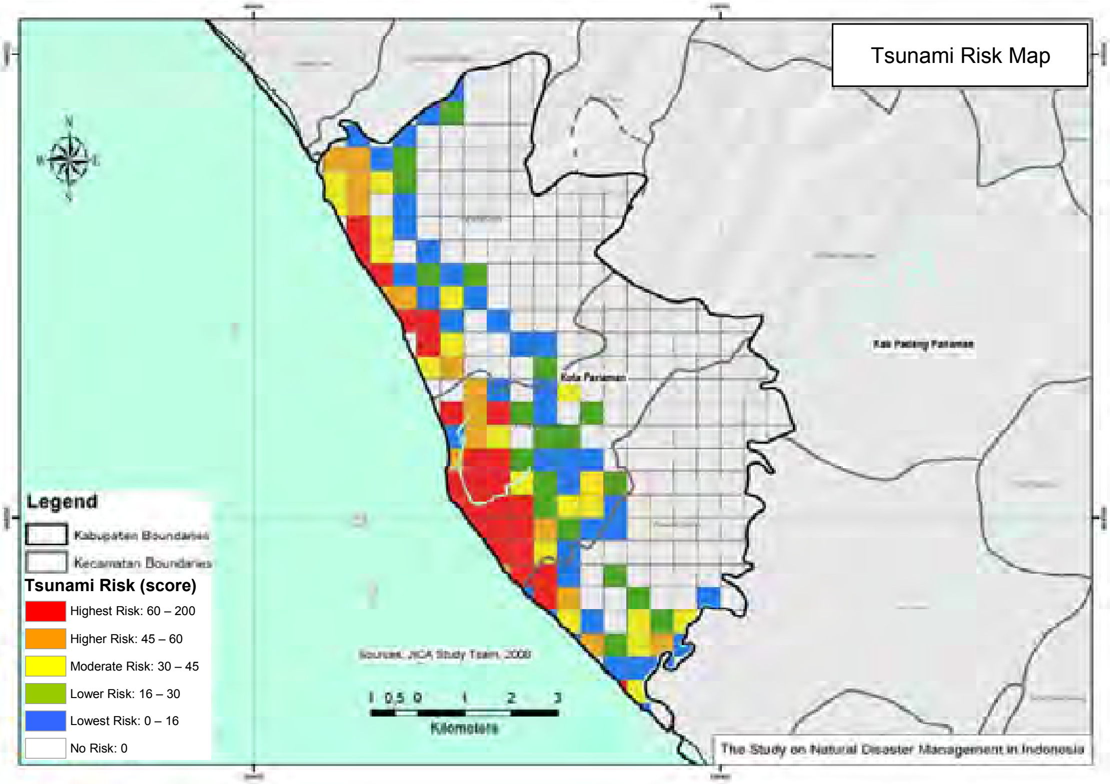


Figure 3.2.30 Tsunami Risk Map for Kota Pariaman

C. Possible Countermeasures against Tsunami Disaster

Possible countermeasures against tsunami for Kecamatans of Kota Pariaman in hazard or risk of tsunami disaster are listed in Table 3.2.27. The countermeasures were classified into two groups: 1) Short-term Countermeasures and 2) Long-term Countermeasures.

D. Activities for Capacity Development

Refer to the corresponding section of Kabupaten Padang Pariaman for tsunami disaster, since all the workshops were held at the same time.

Table 3.2.27 List of Possible Countermeasures against Tsunami Disaster

Kecamatan (Oceanfront Kecamatan)		Existing Condition					Possible Countermeasures	
		Past Coastal Disaster (rising tide)	Evacuation places or high places in 2km from the coast	Coastal Forest in front of settlement	Possibility of relocation	Population Density in the coastal area	Structural Countermeasures	Non-Structural Countermeasures
1	North Pariaman	Yes slightly	Yes	Yes but thin	Low Adequate relocation site is very far.	Comparatively High	**Short-term Countermeasure** - Wave-proof building Some houses are already constructed. - Maintenance of Evacuation site and Route - Installation of Eevacuation sign board **Long-term Countermeasure** - Tide embarkment	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System
2	Central Pariaman	Yes slightly	No	Yes but thin	Low Adequate relocation site is very far.	High	**Short term Countermeasure** - Wave-proof building Some houses are already constructed. - Maintenance of Evacuation site, Route - Construction and Designation of adequate building as Tsunami shelter - Installation of Eevacuation sign board **Long term Countermeasure** - Tide embarkment, Tide barrier - Tsunami floodgate	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System ※ was already installed partly.
3	South Pariaman	Yes slightly	No	Yes but thin	Low Adequate relocation site is very far.	Comparatively High	**Short term Countermeasure** - Wave-proof building Some houses are already constructed. - Maintenance of Evacuation site, Route - Construction and Designation of adequate building as Tsunami shelter - Installation of Eevacuation sign board **Long term Countermeasure** - Tide embarkment	(1)Coastal Forest (2)Regulation of land-use (3)Tsunami hazard map (5)Tsunami Drill (6)Education (7)Early Warning System ※ was already installed partly.

3.2.6 Early Warning System

1) General

There are two measures to mitigate damages of natural disasters: structural and non-structural measures. For flood damage mitigation, regulating the flood discharges by constructing dams and preventing the overflowing of excess floods by constructing river banks are examples of structural measures while methods to minimize the damage by implementing advance evacuation, regulating land use in the flood prone area, etc are some examples of the non-structural measures. Structural measures which can mitigate damage at a certain level are usually cost-intensive and take a longer period to implement. Non-structural measures, on the other hand, are relatively less expensive and effects can be realized sooner, that is, in terms of the reduction of human casualties. However, significant activities such as development of laws, enhancement of the people's awareness and the eventual conversion of awareness into practice in people's daily lives are required so that the effects of these non-structural measures will be sustainable.

Since it will take time to implement structural measures, the earliest implementation of early warning and evacuation (EWE) System is desirable as one of the most effective non-structural measures

The close coordination between BNPB and BPBD as local disaster management agency is quite indispensable for the effective functioning of EWS in terms of nation wide communication network development for sharing disaster information.

2) Basic Understandings of Existing Early Warning and Evacuation in Pilot Regions

A. Kabupaten Jember

In order to prepare the plan of early warning and evacuation in Kabupaten Jember, the basic conditions are summarized below.

a) Existing Condition of Early Warning and Evacuation in Kabupaten Jember

- Although BMG has been developing the telemetering monitoring and early warning system, it is not sufficient to cover all the Kabupaten Jember and will take more time due to some problems such as the deficit of budget.
- Early warning criteria is indefinite.
- Data for setting up the criteria is insufficient.
- Actual and local observation and warning activities are carried out by several agencies; however, they have not been conducted systematically.
- Although basic flow of information transmission has been fixed, standards for warning issuance and concrete procedure for warning dissemination are unclear.
- Evacuation plan including such as evacuation place and evacuation route, is not prepared.

b) General Limitation of Early Warning

- Disasters originating by rainfall are able to issue by the early warning on regional level; however, early warning for tsunami needs an observation system at the national level.
- In order to set the warning criteria, long-term accumulation of accurate data is crucial.
- Although accuracy of warning criteria will be improved by statistical analysis or simulation analysis, it is still difficult to predict the occurrence of disaster with high probability.

c) General Requirement for Early Warning

- For secure warning transmission and dissemination, multiple methods shall be prepared.
- Data transmission methods are desirable to be stable and reliable even during a disaster.
- In order to issue warning or evacuation orders to start actual and secure evacuation activities, information shall be disseminated by the organization and/or individual who is trusted from the people.
- Evacuation place and evacuation route shall be settled in advance and announced to the people.
- People shall fully grasp the relationship between natural phenomena and disasters, and mechanism of disasters.

B. Kabupaten Padang Pariaman and Kota Pariaman

In order to prepare the plan of early warning and evacuation in Kabupaten Padang Pariaman and Kota Pariaman, basic conditions are summarized below.

a) Existing Condition of Early Warning and Evacuation in Kabupaten Padang Pariaman and Kota Pariaman

(Flood and Sediment Disasters)

- Actual and local observation and warning activities are carried out by irrigation agency and communities; however, it has not been conducted systematically.
- Early warning criteria is indefinite.
- Data for setting up the criteria is insufficient.
- Although basic flow of information transmission has been fixed, standards for warning issuance and concrete procedure for warning dissemination are unclear.
- Evacuation plan including such as evacuation place and evacuation route, is not prepared.

(Earthquake and Tsunami)

- Although early warning system using sirens is developed and operated in collaboration with BMG and Province, it is not sufficient to cover all the coastal area of Kabupaten and Kota. As for Kota, a system to receive information directly from BMG has not been developed.

b) General Limitation of Early Warning

- Disasters originating from rainfall are able to issue the early warning on regional level; however, early warning for tsunami needs an observation system at the national level.
- In order to set the warning criteria, long-term accumulation of accurate data is crucial.
- Although accuracy of warning criteria will be improved by statistical analysis or simulation analysis, it is still difficult to predict the occurrence of disaster with high probability.

c) General Requirement for Early Warning

- For the secure warning transmission and dissemination, multiple methods shall be prepared.
- Data transmission methods are desirable to be stable and reliable even during a disaster.
- In order to issue warning or evacuation orders to start actual and secure evacuation activities, information shall be disseminated by the organization and/or individual who is trusted from the people.
- Evacuation place and evacuation route shall be settled in advance and announced to the people.
- People shall fully grasp the relationship between natural phenomena and disasters, and mechanism of disasters.

3) Plan for Early Warning and Evacuation in Pilot Regions

Based on the above basic understanding, the plan for early warning and evacuation in pilot regions was prepared as follows.

a) Objective

The objectives of the plan are:

- Saving people’s lives
- Reduction of property damage

b) Actions/Items to be Conducted

The actions and items to be conducted for effective early warning system are cited below.

(Common)

- Establishment of information transmission route, and determination of transmission methods

  As for the transmission methods, stable and reliable methods such as utilization of traditional and indigenous method of durum, siren, mobile phone, loudspeaker car, etc. will be considered

- Concretization, documentation and popularization of role allocation of each organization/agency and leader/individual related to information transmission and evacuation
- Capacity enhancement to organizations concerned
- Development of leaders, and training for the leader
- Education, public awareness and drills to the people through the community based disaster management activities, such as education about disaster mechanism, drills for secure evacuation and concrete and continuous activities of rainfall measurement by people themselves with the aim of grasping the relationship between disaster and rainfall
- Setting/selection of evacuation place and evacuation route and their popularization
- Accumulation and analysis of disaster data and natural condition data like rainfall data

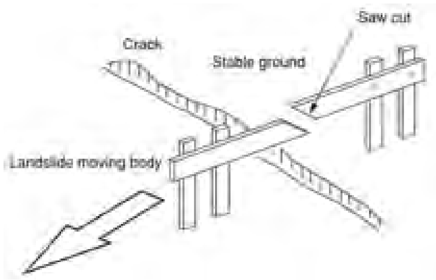
  In cooperation with organizations concerned such as BMG, data about relationship between disaster and natural phenomena shall be accumulated in order to set accurate warning criteria

(Flood)

- Establishment of systematic and integrated hydrological observation system of rainfall and water level and its data transmission system by utilizing existing activities of organizations concerned, in order to develop early warning system
- Accumulation of basic meteorological and hydrological data in order to set warning criteria
- Determination of measuring point of water level and accumulation of data, for setting of warning criteria in high-frequency inundation areas
- Recommendation of location of hydrological stations to be newly installed, and selection of hydrological stations to upgrade observation equipment to a self-recording type or with telemetering function
- Education and increasing public awareness to the people living in high-frequency flood area and flood potential area by using hazard and risk maps

(Sediment Disasters)

- Accumulation of basic meteorological and hydrological data in order to set the warning criteria (same as for floods)
- Education and increasing public awareness to the people living in high-frequency hazard area and hazard potential area by using hazard and risk maps
- Education to the people about relationship between rainfall and sediment disasters
- Simple measurement by people and/or officials in the locations where the predictive phenomena is observed, and education to them about the mechanism of landslide



(Earthquake)

Early warning is extremely difficult.

(Tsunami)

- Establishment of early warning system by BMG
- Development of transmission and dissemination system of BMG's warning to the people (installing siren towers)
- Education about mechanism and risk of tsunami to the people living in coastal areas