No.

NATIONAL DISASTER MANAGEMENT
AGENCY (BNPB)

THE STUDY
ON
NATURAL DISASTER MANAGEMENT
IN
INDONESIA

FINAL REPORT

VOLUME 4:

GENERAL GUIDELINE FOR
FORMULATION OF
REGIONAL DISASTER MANAGEMENT PLAN

MARCH 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.
ASIAN DISASTER REDUCTION CENTER

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Japan International Cooperation Agency (JICA)
BNPB

General Guideline for Formulation of Regional Disaster Management Plan

March 2009

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Part 1: General Guideline

CHAPTER 1. INTRODUCTION

1.1 Background

Indonesia by its geographical and natural conditions suffered from many natural disasters in the past. Especially after Tsunami Disaster caused catastrophic damages in Banda Ache in 2004 reminded the necessity of pre-disaster measures to mitigate, prevent, and prepared for coming natural disasters. By this movement, Law No. 24 concerning Disaster Management was enacted in April 2007. In this law, formulation of Disaster Management Plan is stated for both National and Local Levels and this plan includes measures for pre-disaster phase, emergency response phase, and post-disaster phase to consider all disaster management phases in explicit manner.

In order to avoid confusion and obtain effectiveness in disaster management, formulation of Disaster Management Plan will help to plan, understand, and implement necessary measures in advance, so that disaster management could be implemented aimed, integrated and coordinated and will help to mitigate damages from natural disasters as a result. This plan must be prepared in National level, Provincial Level, and Kota / Kabupaten Level, and these plans must be closely integrated one another to be able to coordinate among all levels of organizations involved in disaster management.

Every region has different hazard characteristics and risks, but disaster management pattern must remain the same, in regard to it, a guideline on formulating disaster management plan is needed.

This guideline is prepared within the scope of "The Study on Natural Disaster Management in Indonesia" financed by Japan International Cooperation Agency (hereinafter referred to as "JICA") and in the course of the Study, Regional Disaster Management Plans in Kabupaten Jember in East Java Province and Kabupaten Padang Pariaman and Kota Pariaman in West Sumatra Province were formulated as Prototype Regional Disaster Management Plan in Indonesia. Therefore, to be able to formulate the plans easily in all the rest of Kota / Kabupaten in Indonesia, these Prototype Plans are attached to this guideline as for your reference to help you understand the contents and easy to formulate the plan by yourself.

1.2 Objective

Formulation of comprehensive disaster management plan is difficult for local government since it is the first time for most of Kota / Kabupaten Government. Therefore, this guideline is utilized as a reference to be able to formulate by yourself. This guideline is especially prepared for Kota /

Kabupaten Government, however, Provincial Government can refer this guideline to formulate Regional Disaster Management Plan in Provincial Level referring the structure of the plan.

1.3 Target Disaster

There are many types of natural disasters in Indonesia, this guideline will focus on following disasters, however, other disaster measures can be formulated in the same manner by referring this guideline. And expected to formulate other types of disaster including volcanic disaster, and accident disaster such as Aviation accident, Train accident, Forest Fire and others, considering possibility of occurrence in your region.

1. Flood
2. Sediment Disaster
3. Earthquake
4. Tsunami

1.4 Revision of the Plan

Regional Disaster Management Plan is a Rolling Plan need to update and modify periodically, therefore, once you formulate Regional Disaster Management Plan, that is just a beginning and continuous efforts are necessary. After establishment of BPBD Kabupaten/Kota, special agency concerning disaster management is recommended to newly established, and this agency is recommended to give a responsibility for revision of the plan. Draft version of revised plan is prepared by the agency, and after completion of the draft, this documents are distributed to responsible agencies in Kota/Kabupaten government and relevant organizations, and modify the contents if necessary by each responsible agencies and relevant organizations. After modification, Disaster Management Agency will collect all modified documents and finalize the plan.

1.5 Interrelations with Regional Disaster Management Plan in Provincial Level

In case of large scale disaster, coordination and support from SATKORLAK PB (BPBD Province) is necessary. SATKORLAK PB (BPBD Province) is necessary to understand contents of each Kota/Kabupaten Regional Disaster Management Plans in advance. For this reason, whenever, Kota/Kabupaten Regional Disaster Management Plans are revised, before finalization of the plan, draft revised plan must be submitted to SATKORLAK PB (BPBD Province) and inspected on the contents carefully. If there is comments or necessary elements to be included in the Plan, Kota/Kabupaten governments need to modify based on comments received from SATKORLAK PB (BPBD Province). Therefore, this inspection procedure is necessary to revise Kota/Kabupaten Regional Disaster Management Plan. Detail procedures of revising Regional Disaster Management Plan is indicated in Chapter 3, 3.4.

CHAPTER 2. STRUCTURE OF THE PLAN

This chapter describes structure of Regional Disaster Management Plan.

2.1 Structure of the Plan

1) Composition of the Plan

Considering target disasters, main part of Regional Disaster Management Plan is separated into two parts, "Part 1: Rain and Strom Disaster Measures" targeting Flood and Sediment Disaster, and "Part 2: Earthquake Disaster Measures" targeting Earthquake and Tsunami Disaster.

In each, part, Section1: General, Section 2: Pre-Disaster Measures, Section 3: Emergency Response Measures, Section 4: Post-Disaster Measures are planed comprehensively.

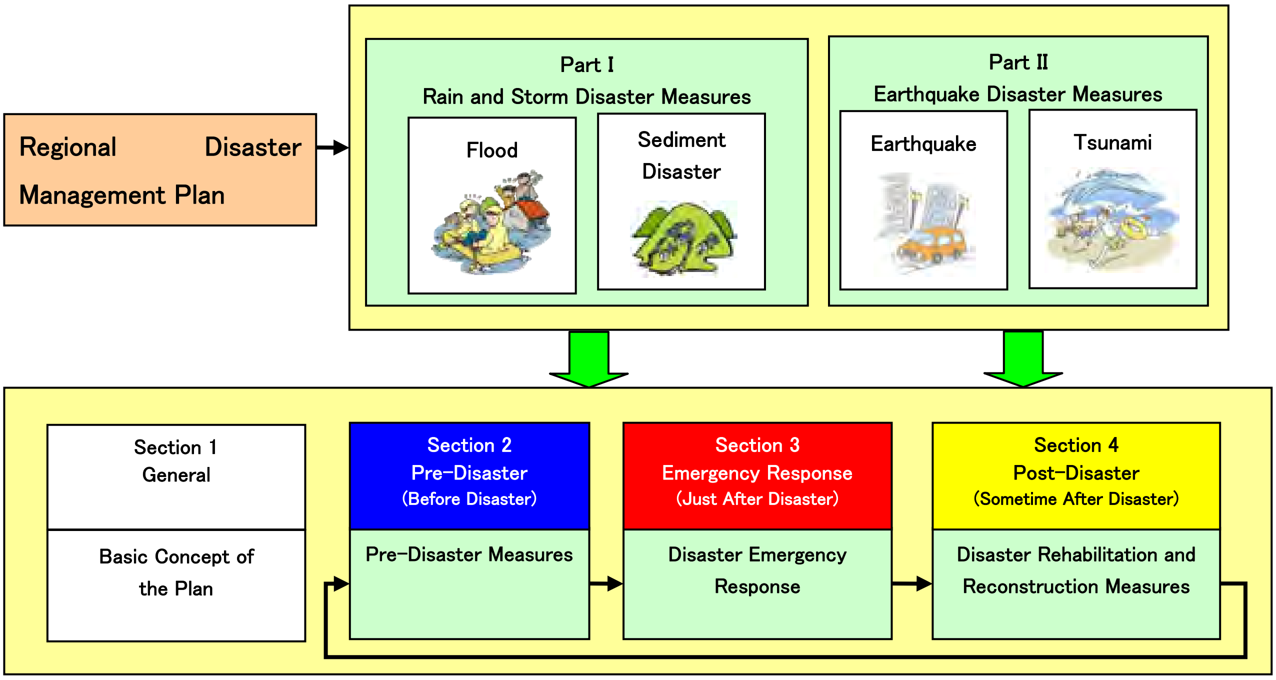


Figure 2.1.1 Categorization and Structure of the Plan

Explanations of each section are mentioned as follows;

(1) Section 1: General

This section describes basic understandings of the Plan including objective, structure of plan, roles of Kota / Kabupaten, and relevant organizations, and disaster characteristics of Kota / Kabupaten formulating Hazard Maps and Risk Maps. Formulation of Hazard Maps and Risk Maps will help to understand target scale of disaster in your region. And to reduce estimated risks in the region, this plan is formulated. How to formulate Hazard Map and Risk Map is included in Appendix 1.

(2) Section 2: Pre-Disaster

This section plans measures for Pre-Disaster including Preparedness, Prevention and Mitigation Measures. To understand roles of Agencies in Kota / Kabupaten Government, responsible agencies are indicated clearly. In recent movement, importance of pre-disaster measures is strongly emphasized and these efforts will greatly mitigate from possible damages, therefore, planning of pre-disaster efforts and their implementations are highly promoted.

(3) Section 3: Emergency Response

This section plans measures for Emergency Response, to help implement emergency response activities effectively and promptly. Responsible Agencies are indicated clearly in order to avoid and minimize unnecessary confusions and conflictions on emergency response activities implemented by agencies and relevant organizations due to disaster occurrence.

(4) Section 4: Post-Disaster

This section plans measures for Post-Disaster including Rehabilitation and Reconstruction. In this section, mainly governmental supports to recover normal life are planed.

As shown in Figure 2.1.2, other than main part of Regional Disaster Management Plan, there are many related documents on disaster management such as relevant laws, regulations, and lists of facilities and resources, etc. Therefore, to avoid confusion, it is recommended to gather all related documents and filed in one document as "Part 3: Appendix". This appendix part will help to find relevant documents easily by anyone dealt with disaster management.

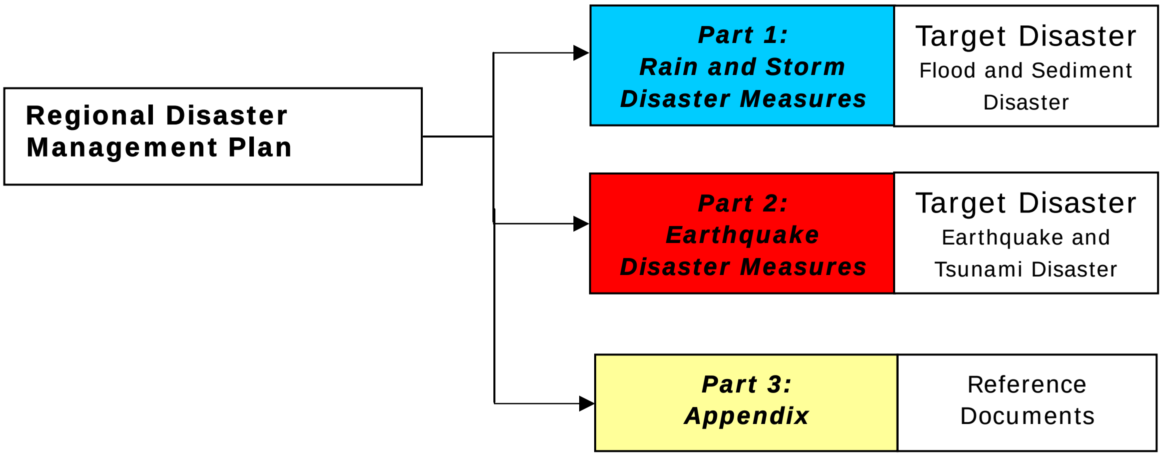
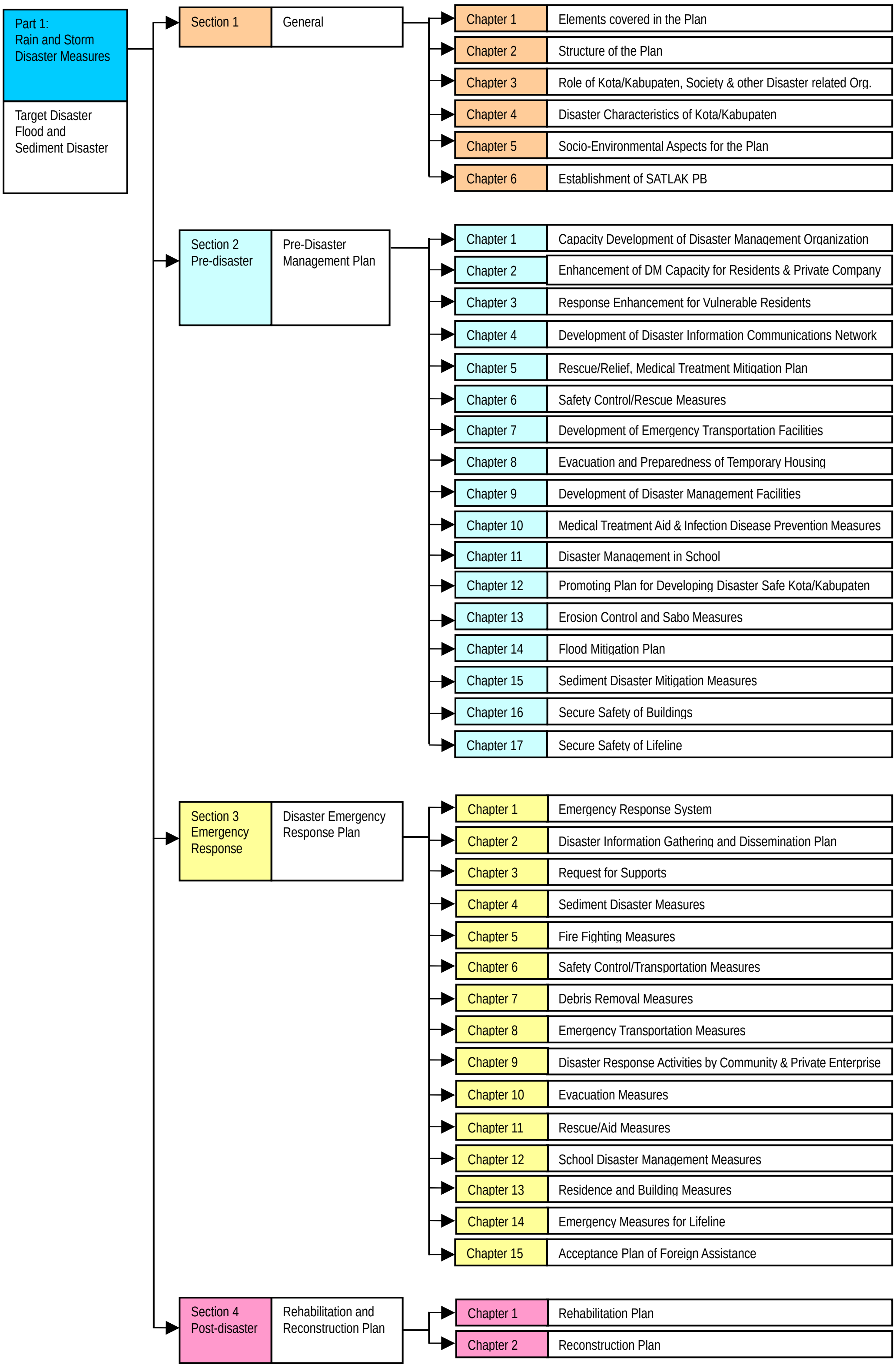


Figure 2.1.2 Composition of the Plan

If the major disaster in your region is earthquake, then you consider changing order of "Part 1: Earthquake Disaster Measures", and "Part 2: Rain and Storm Disaster Measures. Also, when other types of disaster are added, you can easily add additional Parts.

2) Contents of the Plan for “Part 1: Rain and Storm Disaster Measures”

In detail, contents of “Rain and Storm Disaster Measures” are as follows.



Below describes what to mention in each chapters. For more detail on sub chapters, refer to attached Prototype Plan.

(1) Section 1: General

This section indicates general understandings of the plan.

A. Chapter 1: Elements covered in the Plan

This chapter mentions elements covered in the Plan, mainly refer to the Prototype Plan for this Chapter.

B. Chapter 2: Structure of the Plan

This chapter mentions structure of the plan, refer to the Prototype, however, if there are other specific elements your region finds necessary to add, you can do so.

C. Chapter 3: Role of Kota/Kabupaten, Society, and other Disaster related Organizations and

In disaster management, every player includes government, private enterprises, citizens must act closely for mitigating damages from natural disasters, therefore, this chapter mentions roles of Kota/Kabupaten, Disaster related Organizations, and Citizens on disaster management. If your region has PROTAP you can refer to the document.

D.Chapter 4: Disaster Characteristics of Kota/Kabupaten

For effective and appropriate disaster management, you need to understand characteristics of disaster in your region. This chapter includes general indication of Natural Conditions such as geographical condition, climate, Social Conditions such as population and buildings. Also, indicating list of history of floods and sediment disasters help to understand characteristics of disaster. However, most of region does not keep data on past disasters. Therefore, from now on, it is recommended strongly to list and file disaster records and update list periodically to indicate in the plan.

And most important part of this chapter is formulation of Hazard Maps and Risk Maps on Flood and Sediment Disaster to understand Hazard and Risk area in your region. For detail procedure of how to formulate such maps are attached in Appendix 1.

E. Chapter 5: Socio-Environmental Aspects for the Plan

This chapter mentions recent trend and important points of disaster management. You can also refer to the Prototype Plan. However, you can also add topics to this chapter, if you have anything you want to highlight.

F. Chapter 6: Establishment of SATLAK PB (BPBD Kota/Kabupaten)

This chapter mentions definition, duties, structure of SATLAK PB (BPBD Kota/Kabupaten). You can refer to the Prototype Plan, and also if your region has PROTAP, refer to the document.

(2) Section 2: Pre-Disaster Measures

This section plans Pre-Disaster Measures to prepare, prevent and mitigate disasters before occurrence of disasters.

A. Chapter 1: Capacity Development of Disaster Management Organization

To improve disaster management capacity, enhancement of disaster management organizations is necessary. This chapter mentions improvement of RUPUSUDALOPS PBP (Emergency Response Headquarter), supports from extensive area to be able to accept assistants from outside.

B. Chapter 2: Enhancement of Disaster Management Capacity for Residents and Private Companies

Citizens and private enterprises play important roles in disaster management, therefore, in this chapter, expectations to citizens, society, private enterprises, volunteer organization together with dissemination of disaster management knowledge are defined clearly. Also, promotion of implementing drills is also indicated here.

C. Chapter 3: Enhancement of Response to Vulnerable Residents

Elderly, handicapped, infants may need special supports for taking appropriate actions under emergency circumstance. This chapter describes pre-disaster measures for these vulnerable groups.

D. Chapter 4: Development of Disaster Information Communications Network

Effective disaster information communication system will help to mitigate damages against natural disasters, especially for flood, sediment disasters can prevent damages by using effective and prompt information dissemination. This chapter plans future development and enhancement of disaster communication system.

E. Chapter 5: Rescue/Relief, Medical Treatment Mitigation Plan

In this chapter, enhancement of fire fighting capacity, providing education to citizens and communities, are described to enhance capacity of rescue/relief, medical treatment.

F. Chapter 6: Safety Control/Rescue Measures

Police plays important role in safety control and rescue activities, also if there is sea in your region, safety control and rescue measures by sea must be planed.

G. Chapter 7: Development of Emergency Transportation Facilities

In case of occurrence of disaster, closure of transportation will totally disturb emergency response activities, therefore, emergency road network and means of transport must be considered in advance to be able to carry out prompt emergency response activities. Also, airport, heliport, sea port will also be used effectively for emergency transport network.

H. Chapter 8: Evacuation and Preparedness of Temporary Housing

If citizens evacuated due to disaster occurrence to escape from risks, necessary facilities to accept such evacuees must be prepared. Therefore, this chapter mentions role of temporary evacuation areas and evacuation facilities and formulation of evacuation plan in advance.

I. Chapter 9: Development of Disaster Management Facilities

Stockpiles are vital for disaster preparedness such as materials and equipments for damage prevention, rescue activities and restoration. Therefore, this chapter indicates on stockpile of disaster management equipments and goods, food and commodities, and drinking water, and etc.

J. Chapter 10: Medical Treatment Aid and Infection Disease Prevention Measures

In case of disaster occurrence, medical treatment is necessary. Therefore, in this chapter mentions development of activities base of medical treatment, stockpile of medicine and medical equipments and goods, infection disease prevention, etc.

K. Chapter 11: Disaster Management in School

School facilities can be utilized as evacuation facilities, however, due to continuation of evacuation life for long time, school facilities need to operate as original educational function. Also to save pupils life and used as evacuation facilities, school facilities need to be strong enough. In this chapter, formulation of evacuation/derivation/protection plan, preparedness measures for school facilities, etc are indicated.

L. Chapter 12: Promoting Plan for Developing Disaster Safe Kota/Kabupaten

For promoting disaster safe Kota/Kabupaten in the future, effective land use planning, development of disaster mitigation facilities is promoted. This chapter indicates measures on urban development.

M. Chapter 13: Erosion Control and Sabo Measures

Erosion Control and Sabo measures are indicated here. If you region have specific measures to be developed in the future. Please indicate as specific as possible and promote for actual implementation.

N. Chapter 14: Flood Mitigation Plan

Flood mitigation measures are indicated here. If you region have specific measures to be developed in the future. Please indicate as specific as possible and promote for actual implementation.

O. Chapter 15: Sediment Disaster Mitigation Measures

Sediment disaster mitigation measures are indicated here. If you region have specific measures to be developed in the future. Please indicate as specific as possible and promote for actual implementation.

P. Chapter 16: Secure Safety of Buildings

Secure safety of building will help to reduce human loss. This chapter describes importance of building diagnosis, and retrofitting of buildings both in private and public buildings.

Q. Chapter 17: Secure Safety of Lifeline

Utilities referred as “Lifeline” such as Water, Electricity, Telecommunication, and etc. are critical system of our life. Therefore, if these utilities are damaged caused by flood and sediment disasters, urban malfunction will occur, and its effect is considered to be extremely large. In this chapter, existing condition of lifeline facilities are indicated together with measures to mitigate damages such as strengthening of facilities and preparation of disaster management plan by each lifeline companies.

(3) Section 3: Emergency Response

This section plans Emergency Response Measures for effective and prompt emergency response activities to mitigate damages after occurrence of disasters.

A. Chapter 1: Emergency Response System

Appropriate emergency response system can implement effective and prompt emergency response activities. This chapter indicates procedures of establishment of RUPUSUDALOPA PBP (Emergency Response Headquarter) and responsible activities to be carried out by each agencies and relevant organizations.

B. Chapter 2: Disaster Information Gathering and Dissemination Plan

Effective gathering and transmittal of disaster information will help for prompt decision making to mitigate spreading of damages. This chapter indicates means of communication, operation system of disaster communication system, receive and transmit of forecasts and warnings, collection of disaster information, items of information to be collected, and publication of disaster information for helping effective evacuation derivation. These procedures must be understood by every staffs involved for these activities.

C. Chapter 3: Request for Supports

In case of occurrence of large scale disaster, Kota/Kabupaten needs to ask for support from national, provincial government, surrounding Kota/Kabupaten, as well as relevant organizations such as Military, Red Cross and others. This chapter indicates procedure on request for supports.

D. Chapter 4: Sediment Disaster Measures

By giving warnings effectively, human loss from sediment disaster can be prevented. Also, prevention of secondary disaster can also avoid by effective emergency response measures. This chapter indicates sediment disaster measures in emergency response phase.

E. Chapter 5: Fire Fighting Measures

Fire Fighting Organization plays also important role for emergency response activities. Not only limited to fire distinguishing activates caused by occurrence of fire, their capabilities can be utilized for search and rescue operations. This chapter describes, operation system of fire fighting organization.

F. Chapter 6: Safety Control/Transportation Measures

In case of occurrence of disaster, people want to escape from risk, therefore, congestion of traffic is expected in many places. Also, security measures in disaster affected area must be carried out. This chapter indicates procedures of safety control and transportation measures.

G. Chapter 7: Debris Removal Measures

After occurrence of disaster, to implement smooth emergency response activities, spreading of debris on the road will disturbs flow of traffic. Also, for reconstruction to recover normal life, collapsed buildings must be removed. This chapter describes procedure of debris removal.

H. Chapter 8: Emergency Transportation Measures

Obstacles on the street disturbs prompt emergency response activities, this chapter describes how to keep emergency transportation network. Also, how to procure heavy vehicles for clear the road is indicated here.

I. Chapter 9: Disaster Response Activities by Community and Private Enterprises

Not only governments can dealt with disaster emergency response activities and all players include citizens, private enterprises, and community groups, must participate in emergency response activates, this chapter list up what are responsibilities of these players.

J. Chapter 10: Evacuation Measures

Evacuation is one of the most important procedures to prevent from damages to citizens. By giving prompt and appropriate evacuation warnings can avoid human loss. Therefore, in this chapter, criteria for announcing evacuation warnings and evacuation procedure together with how to manage and operate evacuation facility are planed.

K. Chapter 11: Rescue/Aid Measures

After occurrence of disaster, people who evacuated need provision of foods, water and daily commodities. And people injured need first aid and medical treatment, also rescue operations. This chapter mentions rescue and aid measures to help disaster victims.

L. Chapter 12: School Disaster Management Measures

School facilities play important roles after occurrence of disaster such as utilized as evacuation facilities. This chapter indicates management of school, measures for students and pupils, etc.

M. Chapter 13: Residence and Building Measures

Many residential buildings will be damaged by large scale disaster. As a result of disaster, disaster victims will loose their houses. In order to support these refugees, construction of temporally houses and repair of damaged houses shall be planned in this chapter.

N. Chapter 14: Emergency Measures for Lifeline

Recovery of lifeline is indispensable for daily life, in this chapter indicates emergency measures taken by lifeline suppliers for prompt recovery.

O. Chapter 15: Acceptance Plan of Foreign Assistance

International assistance will be expected for large scale natural disaster. Emergency rescue operations including search and rescue, medical service, construction of evacuation facilities and management will be the first necessary items. International aid teams will join immediately after disaster occurrence. In order to accept international assistance for emergency operation, basic acceptance plan including information sharing with national and provincial organization and necessary procedures should be prepared in this chapter.

(4) Section 4: Post-Disaster

This section plans Post-Disaster Measures for appropriate and prompt rehabilitation and reconstruction sometime after occurrence of disasters.

A. Chapter 1: Rehabilitation Plan

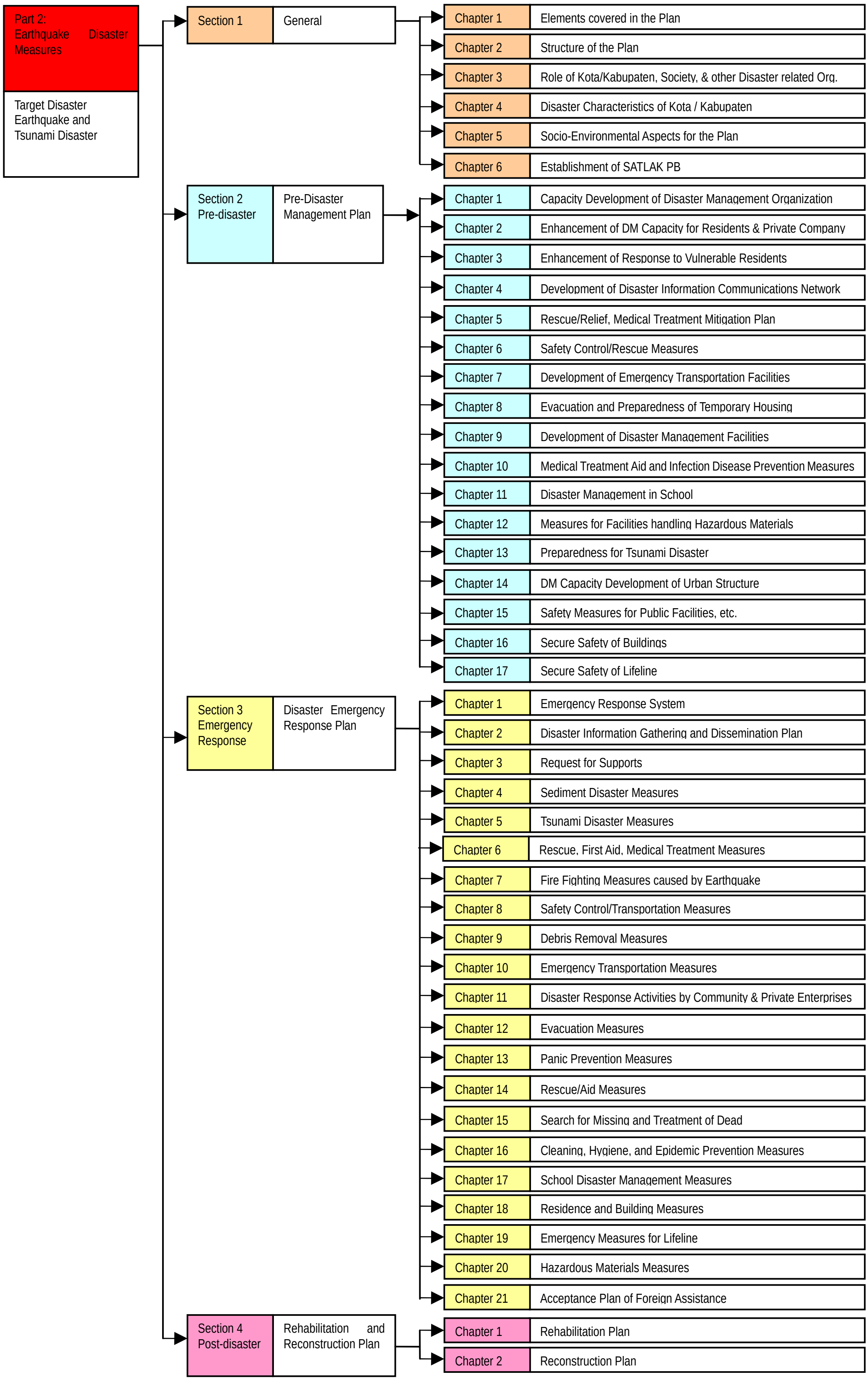
For Rehabilitation Measures, prompt recovery on daily life and facilities of disaster victims, industries, etc. are expected. In this chapter, Kota/Kabupaten government plans, to put citizen's lives back in order, on establishment of inquiry counters, temporary housing measure, emergency funding, etc.

B. Chapter 2: Reconstruction Plan

To reconstruct safe and delightful city by conquering disasters, following basic concept is formulated. This chapter indicates plans for reconstruction.

3) Contents of the Plan for "Part 2: Earthquake Disaster Measures"

Contents of "Earthquake Disaster Measures" are as follows.



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D. Chapter 4: Disaster Characteristics of Kota/Kabupaten

For effective and appropriate disaster management, you need to understand characteristics of disaster in your region. This chapter includes general indication of Natural Conditions such as geographical condition, climate, Social Conditions such as population and buildings. Also indicating list of history of Earthquakes and Tsunamis help to understand characteristics of disaster. However, most of region does not keep data on past disasters. Therefore, from now on, it is recommended strongly to list and file disaster records and update list periodically to indicate in the plan.

And most important part of this chapter is formulation of Hazard Maps and Risk Maps on Earthquake and Tsunami Disaster to understand Hazard and Risk area in your region. For detail procedure of how to formulate such maps are attached in Appendix 1.

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B. Chapter 2: Enhancement of Disaster Management Capacity for Residents and Private Companies

Citizens and private enterprises play important roles in disaster management, therefore, in this chapter, expectations to citizens, society, private enterprises, volunteer organization together with dissemination of disaster management knowledge are defined clearly. Also, promotion of implementing drills is also indicated here.

C. Chapter 3: Response Enhancement for Vulnerable Residents

Elderly, handicapped, infants may need special supports for taking appropriate actions under emergency circumstance. This chapter describes pre-disaster measures for these vulnerable groups.

D. Chapter 4: Development of Disaster Information Communications Network

Effective disaster information communication system will help to mitigate damages against natural disasters, especially for Tsunami disaster, early warning will help to prevent from human loss that people in the coastal area can evacuate before Tsunami arrives at coastal area by using effective and prompt information dissemination. This chapter plans future development and enhancement of disaster communication system.

E. Chapter 5: Rescue/Relief, Medical Treatment Mitigation Plan

In this chapter, enhancement of fire fighting capacity, providing education to citizens and communities, are described to enhance capacity of rescue/relief, medical treatment.

F. Chapter 6: Safety Control/Rescue Measures

Police plays important role in safety control and rescue activities, also if there is sea in your region, safety control and rescue measures by sea must be planed.

G. Chapter 7: Development of Emergency Transportation Facilities

In case of occurrence of disaster, closure of transportation will totally disturb emergency response activities, therefore, emergency road network and means of transport must be considered in advance to be able to carry out prompt emergency response activities. Also, airport, heliport, sea port will also be used effectively for emergency transport network.

H. Chapter 8: Evacuation and Preparedness of Temporary Housing

If citizens evacuated due to disaster occurrence to escape from risks, necessary facilities to accept such evacuees must be prepared. Therefore, this chapter mentions role of temporary evacuation area and evacuation facilities and formulation of evacuation plan in advance.

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K. Chapter 11: Disaster Management in School

School facilities can be utilized as evacuation facilities, however, due to continuation of evacuation life for long time, school facilities need to operate as original educational function. Also to save pupils life and used as evacuation facilities, school facilities need to be strong enough. In this chapter, formulation of evacuation/derivation/protection plan, preparedness measures for school facilities, etc are indicated.

L. Chapter 12: Measures for Facilities handling Hazardous Materials

In case of earthquake disaster, there may be occurrence of fire outbreak at facilities handling hazardous materials such as high pressure gas, LPG, LNG, etc., and these hazardous materials have risks to lead secondary disasters. Toxic Agents and Deleterious Substances have also high risk, if these materials are spread due to earthquake and these effects remain for the long time.

To secure safety of facilities handling these hazardous materials, and avoid occurrence of secondary disaster due to earthquake, necessary measures are planed in this chapter.

M. Chapter 13: Preparedness for Tsunami Disaster

Preparedness measures for Tsunami Disaster are indicated here. If you region have specific measures to be developed in the future. Please indicate as specific as possible and promote for actual implementation.

N. Chapter 14: Disaster Management Capacity Development of Urban Structure

For promoting disaster safe Kota/Kabupaten in the future, effective land use planning, development of disaster mitigation facilities is promoted. This chapter indicates measures on urban development.

O. Chapter 15: Safety Measures for Public Facilities, etc.

Damages of public facilities from earthquake might disturb emergency activities such as evacuation, fire fighting and medical treatment. Especially damages of lifeline could cause strong negative impacts upon the civil life. To mitigate these impacts, concerned agencies take an appropriate action in this chapter.

P. Chapter 16: Secure Safety of Buildings

Secure safety of building will help to reduce human loss. This chapter describes importance of building diagnosis, and retrofitting of buildings both in private and public buildings.

Q. Chapter 17: Secure Safety of Lifeline

Utilities referred as “Lifeline” such as Water, Electricity, Telecommunication, and etc. are critical system of our life. Therefore, if these utilities are damaged caused by flood and sediment disasters, urban malfunction will occur, and its effect is considered to be extremely large. In this chapter, existing condition of lifeline facilities are indicated together with measures to mitigate damages such as strengthening of facilities and preparation of disaster management plan by each lifeline companies.

(3) Section 3: Emergency Response

This section plans Emergency Response Measures for effective and prompt emergency response activities to mitigate damages after occurrence of disasters.

A. Chapter 1: Emergency Response System

Appropriate emergency response system can implement effective and prompt emergency response activities. This chapter indicates procedures of establishment of

RUPUSUDALOPA PBP (Emergency Response Headquarter) and responsible activities to be carried out by each agencies and relevant organizations.

B. Chapter 2: Disaster Information Gathering and Dissemination Plan

Effective gathering and transmittal of disaster information will help for prompt decision making to mitigate spreading of damages. This chapter indicates means of communication, operation system of disaster communication system, receive and transmit of forecasts and warnings, collection of disaster information, items of information to be collected, and publication of disaster information for helping effective evacuation derivation. These procedures must be understood by every staffs involved for these activities.

C. Chapter 3: Request for Supports

In case of occurrence of large scale disaster, Kota/Kabupaten needs to ask for support from national, provincial government, surrounding Kota/Kabupaten, as well as relevant organizations such as Military Red Cross and others. This chapter indicates procedure on request for supports.

D. Chapter 4: Sediment Disaster Measures

By giving warnings effectively, human loss from sediment disaster caused by earthquake can be prevented. Also, prevention of secondary disaster can also avoid by effective emergency response measures. This chapter indicates sediment disaster measures in emergency response phase.

E. Chapter 5: Tsunami Disaster Measures

When the cruel movement is caused by earthquake at the sea bottom, it is assumed that the tsunami occurs. In addition, there are some cases that even if the earthquake is not felt in the case of small earthquake that occurred in the seas close to shore and the case of the earthquake that occurred in the distant seas, huge tsunami rushed suddenly. In this chapter, emergency response is planed when tsunami occurs.

F. Chapter 6: Rescue, First Aid, Medical Treatment Measures

If large scale disaster occurs, rescue, first aid, medical treatment activities must be implemented systematically as possible. In this chapter, Rescue, First Aid, Medical Treatment Measures are planed.

G. Chapter 7: Fire Fighting Measures caused by Earthquake

There are risks of fire outbreak where construction materials of houses are flammable such as woods, bamboos, and etc. Fire Fighting Organization plays also important role for emergency response activities. Not only limited to fire distinguishing activates caused by occurrence of fire, their capabilities can be utilized for search and rescue operations. This chapter describes, operation system of fire fighting organization.

H. Chapter 8: Safety Control/Transportation Measures

In case of occurrence of disaster, people want to escape from risk, therefore, congestion of traffic is expected in many places. Also, security measures in disaster affected area must be carried out. This chapter indicates procedures of safety control and transportation measures.

I. Chapter 9: Debris Removal Measures

After occurrence of disaster, especially devastating earthquake and Tsunami will destroy buildings, trees, and so on. To implement smooth emergency response activities, these debris on the road will disturbs flow of traffic. Also, for reconstruction to recover normal life, collapsed buildings must be removed. This chapter describes procedure of debris removal.

J. Chapter 10: Emergency Transportation Measures

Obstacles on the street disturbs prompt emergency response activities, this chapter describes how to keep emergency transportation network. Also, how to procure heavy vehicles for clear the road is indicated here.

K. Chapter 11: Disaster Response Activities by Community and Private Enterprises

Not only governments can dealt with disaster emergency response activities and all players include citizens, private enterprises, and community groups, must participate in emergency response activates, this chapter list up what are responsibilities of these players.

L. Chapter 12: Evacuation Measures

Evacuation is one of the most important procedures to prevent from secondary disasters caused by fire outbreaks and collapse of buildings caused by aftershocks. By giving prompt and appropriate evacuation warnings can reduce human loss. Therefore, in this chapter, criteria for announcing evacuation warnings and evacuation procedure together with how to manage and operate evacuation facility are planed.

M. Chapter 13: Panic Prevention Measures

In case of occurrence of strong earthquake, various types of disasters will be caused at various places simultaneously. Social panic will be expected to happen due to disaster. In order to prevent social panic, this chapter indicates plans to prevent panic.

N. Chapter 14: Rescue/Aid Measures

After occurrence of disaster, people who evacuated need provision of foods, water and daily commodities. And people injured need first aid and medical treatment, also rescue operations. This chapter mentions rescue and aid measures to help disaster victims.

O. Chapter 15: Search for Missing and Treatment of Dead

In case of occurrence of devastating disaster, unfortunately, there will be many missing and dead. Therefore, in reality, search for missing and treatment of dead must be planed in this chapter.

P. Chapter 16: Cleaning, Hygiene, and Epidemic Prevention Measures

In case of occurrence of devastating disasters, due to lack of water supply, there will be problems for hygiene and epidemics. To prevent from such problems, measures for health care and hygiene, treatment of solid and human waste, and epidemic prevention should be planed in this chapter.

Q. Chapter 17: School Disaster Management Measures

School facilities play important roles after occurrence of disaster such as utilized as evacuation facilities. This chapter indicates management of school, measures for students and pupils, etc.

R. Chapter 18: Residence and Building Measures

Many residential buildings will be damaged by large scale disaster. As a result of disaster, disaster victims will loose their houses. In order to support these refugees, construction of temporally houses and repair of damaged houses shall be planned in this chapter.

S. Chapter 19: Emergency Measures for Lifeline

Recovery of lifeline is indispensable for daily life, in this chapter indicates emergency measures taken by lifeline suppliers for prompt recovery.

T. Chapter 20: Hazardous Materials Measures

Hazardous materials are sometimes critical especially for earthquake disaster causing fire outbreaks. This chapter indicates measures for facilities handling hazardous materials.

U. Chapter 21: Acceptance Plan of Foreign Assistance

International assistance will be expected for large scale natural disaster. Emergency rescue operations including search and rescue, medical service, construction of evacuation facilities and management will be the first necessary items. International aid teams will join immediately after disaster occurrence. In order to accept international assistance for emergency operation, basic acceptance plan including information sharing with national and provincial organization and necessary procedures should be prepared in this chapter.

(4) Section 4: Post-Disaster

This section plans Post-Disaster Measures for appropriate and prompt rehabilitation and reconstruction sometime after occurrence of disasters.

A. Chapter 1: Rehabilitation Plan

For Rehabilitation Measures, prompt recovery on daily life and facilities of disaster victims, industries, etc. are expected. In this chapter, Kota/Kabupaten government plans, to put citizen’s lives back in order, on establishment of inquiry counters, temporary housing measure, emergency funding, etc.

B. Chapter 2: Reconstruction Plan

To reconstruct safe and delightful city by conquering disasters, following basic concept is formulated. This chapter indicates plans for reconstruction.

2.2 Important Elements in the Plan

There are important elements to be considered in formulation of Regional Disaster Management Plan as mentioned below;

1) Understanding Disaster Characteristics of Your Region and Formulation of Hazard and Risk Maps for Target Disasters

Unless you don't know the target disaster and scale of disaster in your region, the plan will not be accurate enough. Therefore, a first step to start formulation of Regional Disaster Management Plan is to formulate Hazard Maps and Risk Maps. For detail procedure of formulation of these maps, refer to Appendix 1 in this guideline.

2) Clarify Duties and Roles of Local Government and relevant Organizations in Disaster Management

In disaster management, many agencies in Kota/Kabupaten government, relevant organizations are involved for all pre-disaster, emergency response, post-disaster measures. Therefore, to avoid unnecessary confusion and conflict among all parties, it is necessary to indicate roles by each agency. For example, you can refer to "Part 1: Rain and Storm Disaster Measures, Section 3: Emergency Response, Chapter 1, 1.3, 3), (2) Role of Each Agencies of RUPUSUDALOPS PBP.

3) Procedures of Establishment of RUPUSUDALOPS PBP (Emergency Response Headquarter)

Considering scale of disaster, prompt decision making to establish RUPUSUDALOPS PBP is indispensable for quick response. In order to understand standard procedure of establishment of RUPUSUDALOPS PBP, it is necessary to indicate clearly in the plan for this procedure. Also, criteria for establishment are decided considering local conditions.

4) Means and Contents of Disaster Information Transmission among relevant Organizations and Dissemination to Citizens

Prompt disaster information gathering and transmission will help to reduce spreading of damages and occurrence of secondary disasters. In case of earthquake disaster, normal telecommunication system probably under malfunction and necessary information can not be gathered and transmitted among relevant organizations. Also, information dissemination to citizens can not be effectively carried out. It is necessary to prepare several alternative communication systems to secure important lifeline.

5) Transmittal of Evacuation Warnings and Designation of Evacuation Area in Advance

Evacuation is one of the most important activities in emergency response to reduce spreading of damages and occurrence of secondary disasters. Appropriate evacuation warnings will help mitigate unnecessary human losses. Criteria for announcing evacuation warnings, together with evacuation derivation procedures must be carefully planed. Also, designation of evacuation area (facilities) is effective that citizens in the area know where to evacuate in case of disaster occurrence. Firstly, inventory of schools, mosques, public facilities, which can be utilized as evacuation facilities is prepared, including structure and size of facility, so that capacity of evacuees can be calculated (normally 2 m^2 per person). Also, location map should be prepared. This list with capacity and location map is recommended to include in the main text of Regional Disaster Management Plan or Part 3: Appendix.

6) Increase Awareness and Participation of Citizens and Public Enterprises and coordination with Volunteers, NPOs, and NGOs in Disaster Management

Increase awareness of citizens and public enterprises, and coordination with volunteers, NPOs, and NGOs will greatly reduce damages form natural disasters, enhancement and education to these parties and drills to experience actual emergency response activities will reduce panic in emergency circumstances. Government need to support such activities continuously and systematically.

CHAPTER 3. FUTURE CONSIDERATIONS TO IMPROVE REGIONAL DISASTER MANAGEMENT PLAN

Prototype Plan which attached as Appendix to this guideline is useful reference for formulating Regional Disaster Management Plan in your Kota/Kabupaten. However, there is no goal for disaster management, and social conditions changes time to time, therefore, the plan must be revised and upgraded periodically as this is the rolling plan.

In this chapter, future considerations to improve the plan are proposed.

3.1 Dissemination of Information of the Plan to Public

After formulation of the Regional Disaster Management Plan in your region, it is strongly recommended to disseminate information on the plan to your citizens. The way of dissemination can be distributed by mentioning on your Homepage of Kota/Kapupaten Government, preparation of summary version of the plan as a format of pamphlet, and others. It is important to inform to public that government pays great efforts on disaster management and motivate citizens to help each other and increase awareness on disaster management.

3.2 Confirmation of Procedures of Emergency Response Activities

In Regional Disaster Management Plan, procedures of Emergency Response Activities are indicated such as establishment of Emergency Response Headquarters, staff mobilization, damage information collection and dissemination, and many others. To check and evaluate appropriateness and effectiveness of these procedures, it is necessary to carry out “Table Top Exercise” and “DIG” (Disaster Imagination Game). By carrying out these exercises, problems can be found in these procedures in the plan and need to modify found problems from these exercises. Also carrying out of Drills to actually implement in the field as “Comprehensive Disaster Management Drills” are effective to evaluate actual movement in emergency response.

Table Top Exercise

3.3 Disaster Management Mascot Contest

Important fact of disaster management is to enhance capacity of citizens. To increase their understanding and importance of disaster management, creation of "Disaster Management Character" is one good idea to make citizens interested in disaster management. This mascot will utilize to give image of disaster management to citizens and final purpose is that once citizens see this mascot, they can imagine about disaster management.

In case of Kabupaten Jember, East Java Province, "Disaster Management Character Contest" was hold in February 2008 and more than 120 Mascots were nominated from 43 applicants. The Selection Committee was formulated consists of mainly members from SATLAK PB and selected Top 3 Mascots, and Top 3 mascots were awarded directly form Bupati. Top 1 mascot will be Disaster Management Mascot for Kabupaten Jember and this mascot will be shown in many places regarding Disaster Management. Also, the same Contests were hold in Kabupaten Padang Pariaman and Kota Pariaman.

One important point is copyright of mascot, it is recommended to indicate in the announcement of the Contest that "all the copyright will be transfer to SATLAK PB for disaster management use only" to avoid unnecessary conflict with producer of the mascot.

Kabupaten Jember

Kabupaten Padang Pariaman

Kota Pariaman

3.4 Formulation of "Part 3: Appendix"

The Prototype Plan does not include "Part 3: Appendix". However, as mentioned before, all the related documents together with list of contacts, resources, facilities are recommended to file in this "Part 3: Appendix". Following lists, documents, and diagrams can be considered to be included in Part 3, however, you are free to add documents, lists, figures, and others.

1) List of Contacts

1. List of Disaster Management relevant Organizations,

2. List of Organizations and Private Enterprises contracted for support in case of disaster,
3. List of Medical Support Organizations,
4. List of Contact for Military Support, and etc

2) Information Transmission

1. Diagram of Information Transmission,
2. Diagram of Information Dissemination to Public,
3. Format of Recording Disaster Situation,
4. Procedure of Sharing Information with Relevant Organizations, and etc.

3) Evacuation

1. List of Candidate Evacuation Areas (Facilities),
2. Location Map of Candidate Evacuation Areas (Facilities), and etc.

4) Lifeline

1. List of Water Reservoirs and their capacity,
2. List of Swimming Pools,
3. List of Other Water Resources can be utilized for Emergency Use, and etc.

5) Commodities and Materials for Recovery

1. List of Emergency Commodities and their location,
2. List of Stockyard of Materials for Recovery Activities, and etc.

6) Emergency Transport

1. List of Candidate Area for Heliports,
2. List of Emergency Transportation Network,
3. List of Bridges on Emergency Transportation Network, and etc.

7) Laws, Regulations, and Agreements

1. Laws related to Disaster Management,
2. Regulations related to Disaster Management,
3. Agreements related to Disaster Management, and etc.

8) Disaster Risk

1. List of Steep Slope Location with Danger of Landslides,

2. List of Rivers with Risk of Mud Flow,

3. List of Tsunami Risk Area, and etc.

9) Others

1. List of Community Organizations for Disaster Risk Managing,

2. List of Fire Fighting Stations, and etc.

3.5 Establishment of Specialized Disaster Management Agency in Kota/Kabupaten Government

At present, SATLAK PB is a non permanent body dealt with disaster management, and many agencies are involved. However, pre-disaster measures are important to reduce possible damages form disaster. Therefore, due to enact of Law No. 24, BPBD will be established, therefore, together with establishment of BPBD, it is recommended to establish "Disaster Management Agency" in Kota/Kabupaten Government, in order to strengthening disaster management in permanent basis.

This newly established agency can be act as follows:

1) Normal Period:

1. Act as Secretariat of SATLAK PB,

2. Update and Modify Regional Disaster Management Plan with coordination of relevant agencies and organizations,

3. Plan, Coordinate and Implement Pre-disaster measures to mitigate damages in the future, and etc.

2) Disaster Period:

1. Act as secretariat of RUPUSDALOPS PBP, and etc.

3.6 Close integration with Regional Disaster Management Plan in Provincial Level

Regional Disaster Management Plan in Kota/Kabupaten Level are formulated with SATLAK PB, however, after establishment of BPBD it is recommended to establish "Disaster Management Agency" at the same time, and let this agency to coordinate to formulate Regional Disaster Management Plan. When first draft of Regional Disaster Management Plan is formulated by "Disaster Management Agency", distribute the first draft to each agencies and relevant organizations responsible for activities in pre-disaster, emergency response, and post-disaster,, appointed in each sub-chapters, and carefully examine the contents by these agencies and relevant organizations, and submitted to revised documents to “Disaster Management Agency” to revise the first draft. And as mentioned before, contents of the plan must be closely integrated with Regional Disaster Management Plan in Provincial Level, so that after the first draft was formulated, this first draft must be submitted to Provincial BPBD for their inspection on the contents, and after receiving comments, Kota/Kabupaten BPBD modify the contents again and resubmit to Provincial BPBD for final approval. After receiving final approval by Provincial BPBD, the plan must be discussed in Kota/Kabupaten BPBD and approved by Kota/Kabupaten BPBD.

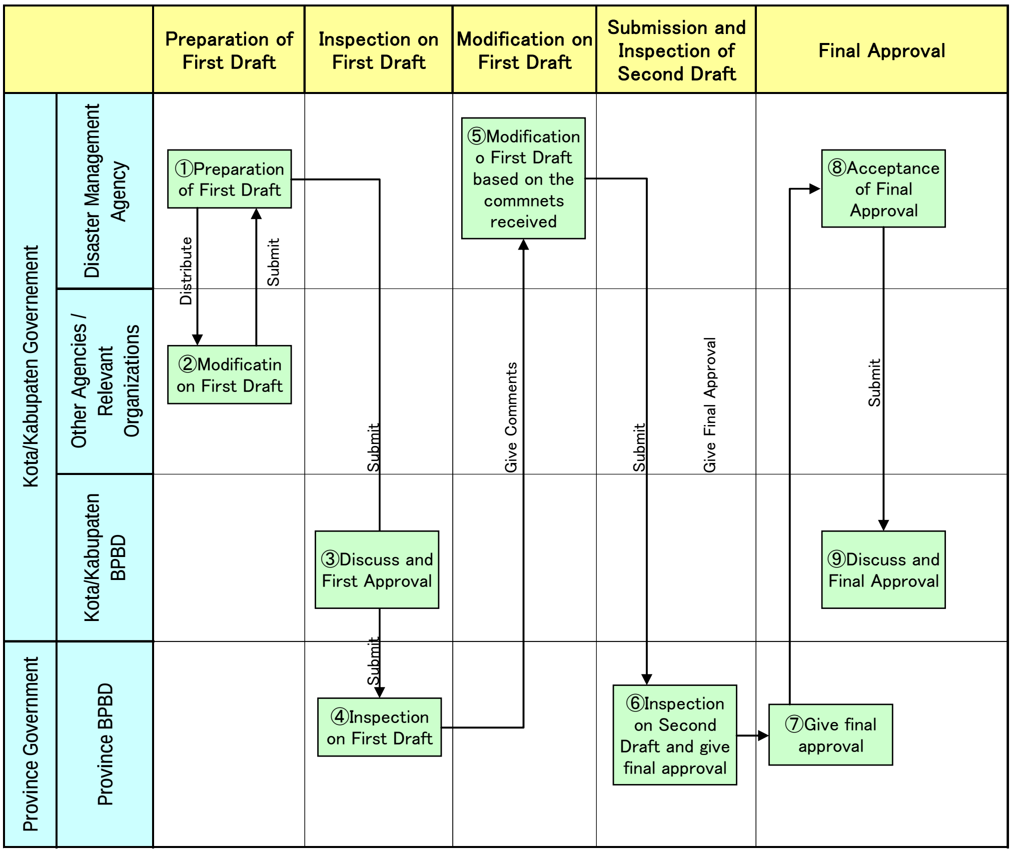


Figure 3.6.1 Procedures of Approval of Regional Disaster Management Plan

Appendix 1:

Guideline for Creations of Hazard Maps and Risk Maps for Natural Disasters

March 2009

Table of Contents

Foreword

"General Guideline for Formulation of Regional Disaster Management Plan" is a practical reference for preparation of regional disaster management plan for local governments in Indonesia. Additionally, maps, showing natural disaster hazards as well as risks, are also necessary as reference for preparation of regional disaster management plan.

As a matter of fact, the hazard maps and risk maps were created especially for 1) sediment disaster, 2) flood disaster, 3) earthquake disaster and 4) tsunami disaster for Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman as basic references for formulation or revision of the regional disaster management plans with the close collaborations between the JICA study team and the relevant counterpart organizations.

In this draft guideline, a simplified procedure is proposed for creations of hazard maps and risk maps for natural disasters on the basis of the hazard maps and risk maps prepared during the study by making use of a GIS (Geographic Information System) software package. However, it is possible to use simpler methods to make the maps in view of the constraint conditions (*e.g.* budget, available skill, *etc*.). Further, this draft guideline also does NOT intend to impede the more advanced methodologies (*e.g.* Flood simulation model, *etc*.) for the creations of hazard maps and risk maps.

JICA Study Team for the Study on Natural Disaster Management in Indonesia

March, 2009

1 OBJECTIVE

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

1) to identify the areas which are considered to be high-risk to natural disasters, and

2) to identify problems facing the area of concern for consideration in the preparation of regional disaster management plan.

In fact, 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 (Kabupaten Jember, Kabupaten Padang Pariaman and Kota Pariaman), since it was aimed at the counterpart members who were 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.

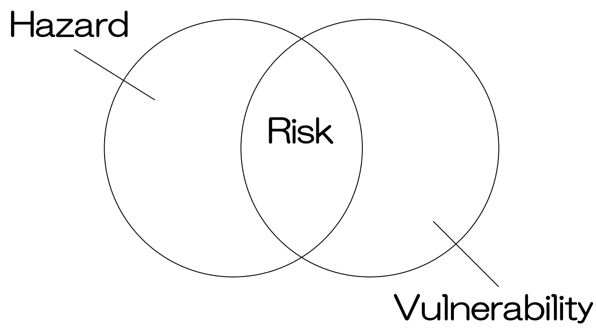
Risk = Hazard x Vulnerability

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 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 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 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.

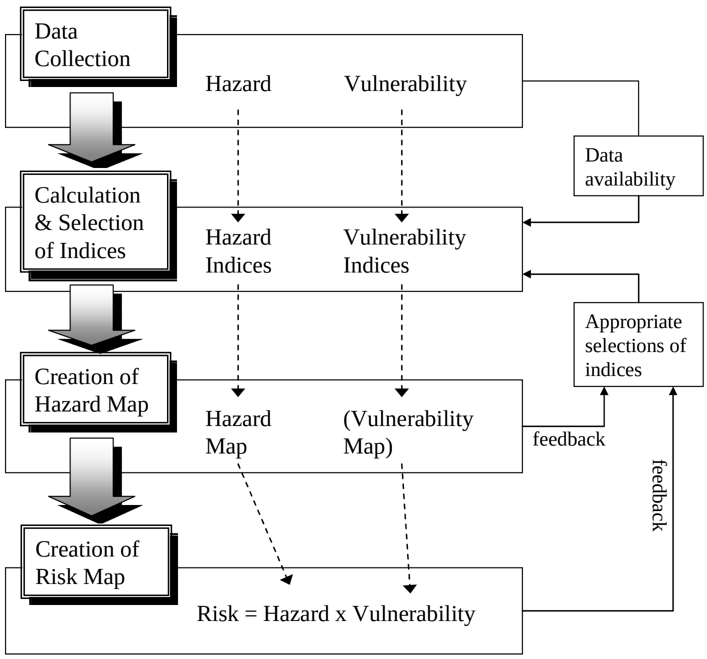


Figure2 Conceptual Flow Chart for Creations of Hazard Maps and Risk Maps

Figure 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.

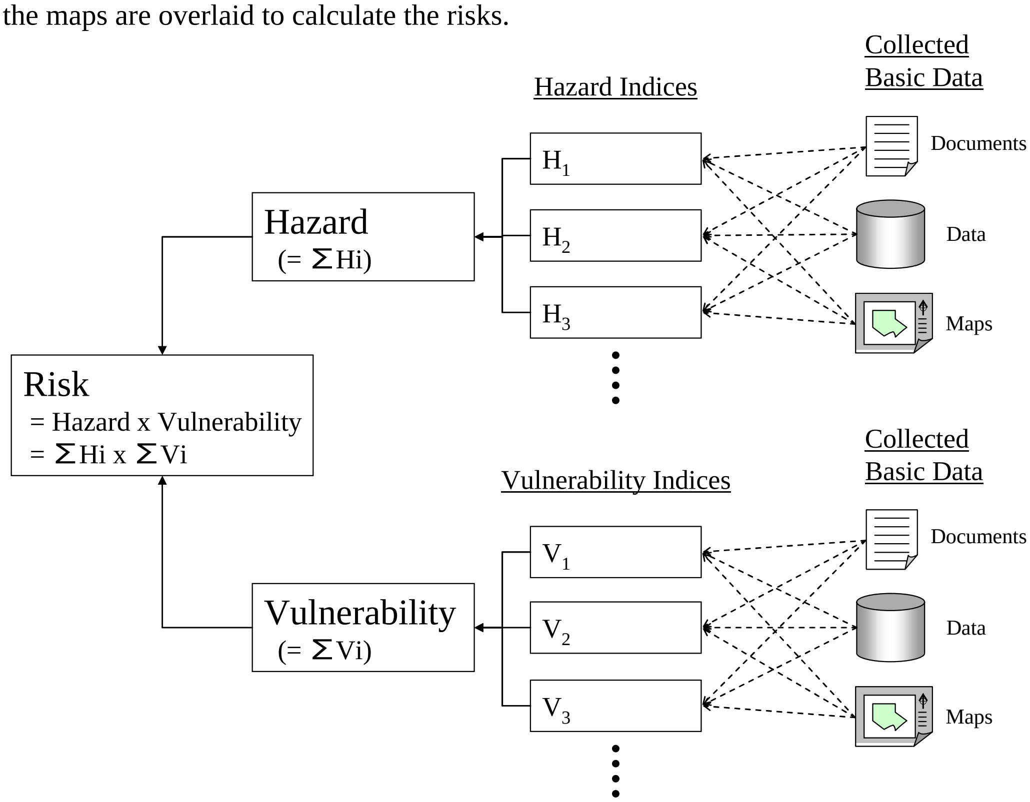


Figure3 Relations among Risk, Hazard, Vulnerability, Indices and Basic Data

The applied size of the grid for Kabupaten Jember and Kabupaten Padang Pariaman were 1 x 1 km for the analyses. Refer to Figure 4 showing the grid map of Kabupaten Jember as an example. 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.

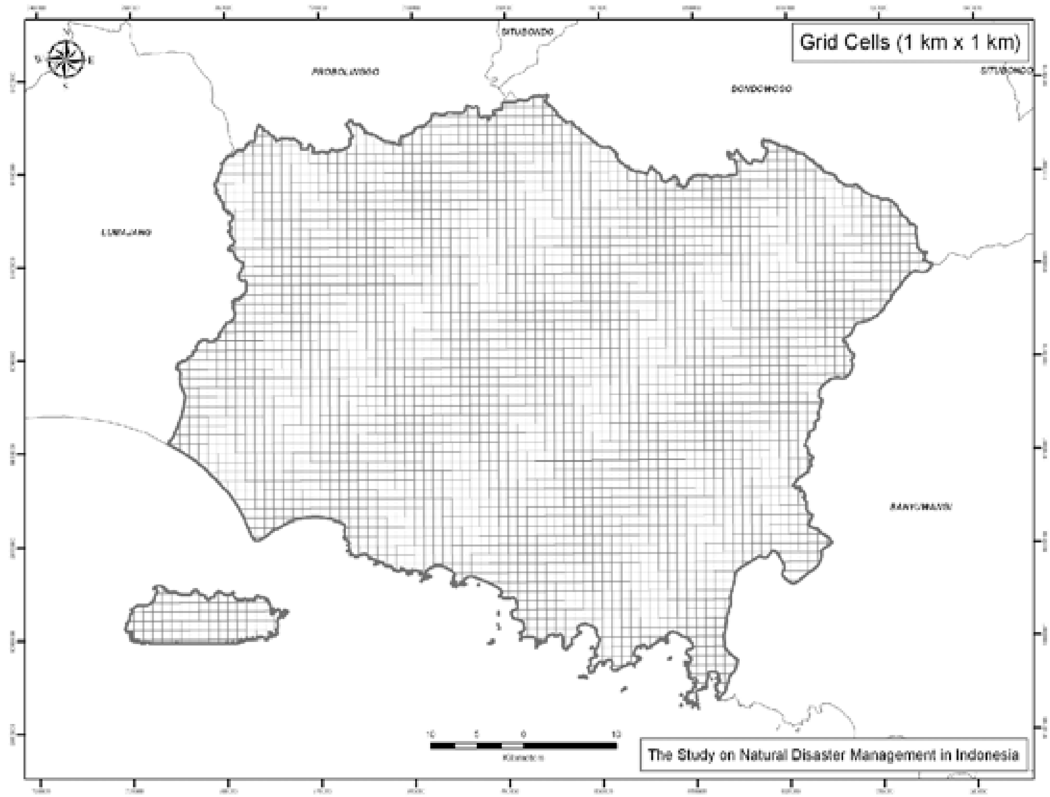


Figure4 Grid Cell (1 x 1km) Map for Kabupaten Jember

4 DATA COLLECTION

Basic data in terms of hazard and vulnerability should be collected from the relevant organizations in consideration of appropriate derivations of hazard map and risk map within the expected data availability, budget, technical skill, *etc.*

Data collection from various information sources

It is indispensable to collect data from the various information sources especially from the relevant organizations. Some electronic data (*e.g.* satellite image, spreadsheet, document, map image, *etc.*) can be also be downloaded through the internet. It is recommended that a preliminary study in view of expected data availability, budget, technical skill, *etc.* should be performed prior to the data collection so that the appropriate derivations of hazard map and risk map will be carried out.

Basic data to be collected in terms of "Hazard"

In general, the data in relation to "Hazard" may be categorized as follows:

- Past disaster affected area (*e.g.* flood area, tsunami affected area, *etc.*)
- Main causes which trigger or triggered disaster (*e.g.* rainfall, ground surface inclination, *etc.*)
- Damage data (*e.g.* damage amount, number of killed or injured, *etc.*)

For instance, the data for sediment disaster in relation to "Hazard" can be past disaster area, rainfall, ground surface incline, ground surface condition, past damage data such as damage amount, number of killed or injured, number of damaged houses, *etc.* As for the flood disaster data may be past inundation area (including depth, duration, *etc.*), rainfall, ground surface incline, ground surface condition, elevation, river & channel network profiles, river facilities (*e.g.* dike, bridge, revetment, *etc.*), past damage data, etc.

Basic data to be collected in terms of "Vulnerability"

"Vulnerability" data should be the data representing the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards (*e.g.* population density, poverty rate, literacy rate, land use, *etc.*).

Table 1 shows the data items to be collected for preparation of indices of hazard and vulnerability.

Table 1 Data items to be collected for indices of hazard and vulnerability

Basic Data	- Administrative Boundary - Cencus Data (Population, Land Use, Road, Infrastructure, etc.) - Topographical Map (1/25,000, 1/50,000, 1/100,000, 1/250,000, etc.) - Digital Elevation Map including Slope - Satellite Image - Geology Map, etc.
Flood Disaster	- Observation Data (Rainfall, Water Level) - Location of Observatory Station - Location Map for Flood Disasters in the past (Area, Depth, Duration) - Disaster Prone Area Map for Flood Disasters - List of Flood Disasters in the past - List of Rivers incl. Name, Length, Max. Discharge, etc. - List of Irrigation Channel incl. Name, Length, Max. Discharge, etc. - List of Drainage incl. Name, Length, Max. Discharge, etc. - River Basin, Catchment Area - Map indicating River Network, Irrigation Channel Network and Drainage Network - Longitudinal of Rivers, Irrigation Channel Network and Drainage Network - Cross-sections of Rivers, Irrigation Channel Network and Drainage Network - Annual Report for Flood Disaster if any - River Basin Management Plan, River Improvement Plan - State of Structural Contermeasures - State of Non-Structural Countermeasures, etc.
Sediment Disaster	- Rainfall Observation(hourly rainfall depth) - Location of Observatory Station - Location Map for sediment disasters in the past - Disaster Prone Area Map for sediment disasters - List of sediment disasters in the past - Report for sediment disaster in the past - River Basin, Catchment Area - River Basin Management Plan - River Improvement Plan - State of Structural Contermeasures - State of Non-Structural Countermeasures, etc.
Earthquake Disaster	- List of Past Earthquake Disaster Profiles (Year, Magnitude, Location, Damages, etc.) - Report regarding characteristics of seismic source - Report regarding seismic analysis in terms of probabilistic method - Report describing the past earthquake disaster especially for ground surface acceleration intensity - Report describing the past earthquake disaster especially for number of damaged buildings by building types - Number of building by building types - Report describing the characteristics of earthquake-resistance strength, etc.
Tsunami Disaster	- Tidal Data - Location of Tidal Observatory Station - List of Tsunami Disasters in the past - Records of Past Tsunami Run-up Height - Tidal Records of Past Tsunami - Records of Damage due to Past Tsunami - Information of Fault model of Past Tsunami - Location Map for Tsunami Disasters in the past (Area, Depth) - Location of Existing Shelter for Tsunami Hazard - Disaster Prone Area Map for Tsunami Disasters - Longitudinal of Rivers, Irrigation Channel Network and Drainage Network - Cross-sections of Beach and Shore Protection Facilities - Cross-sections of Rivers, Irrigation Channel Network and Drainage Network - Coastal Protection Plan - State of Structural Contermeasures - State of Non-Structural Countermeasures - Bathymetry Data - Digital Elevation Map of Low-lying Area near Coast, etc.
Vulnerability Data	- Population by Kecamatan, Desa, etc. - Area by Kecamatan, Desa - Land cover or Land use for Built-up Area - Land cover or Land use for Rice Field & Plantation - Road, Railway Network

5 CALCULATION AND SELECTION OF INDICES

Firstly, the candidate indices for hazard and vulnerability can be calculated based on the collected data. 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.

On the basis of the collected basic data, the candidate indices for hazard and vulnerability, first of all, can be derived. Subsequently, 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.

For example, "Inundation area and depth estimated by level filling method", "Inundation area based on historical inundation records" and "Inundation area and depth estimated based on ground elevation" were taken as the candidate indices for tsunami disaster hazard during the JICA study for Kabupaten Padang Pariaman. Finally, "Inundation area and depth estimated based on ground elevation" were selected as the hazard indices after the trial derivations of hazard map and risk map.

The indices used for creation of hazard maps and risk maps are shown in the table below. Symbol in parentheses in the table indicates symbol of each index.

Table 2 Indices used for creation of hazard maps and risk maps

Disaster Type	Kabupaten Jember		Kabupaten Padang Pariaman and Kota Pariaman	
	Hazard Indices	Vulnerability Indices	Hazard Indices	Vulnerability Indices
Flood disaster	・ Past flood area and flood potential area (H_{J7})	・Population Density (V_{J1}) ・Built-up Area (V_{J2}) ・Vegetation/Cultivated Area (V_{J5})	・Flatness (Slope) (H_{P7}) ・Alluvium (Geology) (H_{P8}) ・Flood Depth (H_{P9}) ・Flood Duration (H_{P10})	・Population Density (V_{P1}) ・Built-up Area (V_{P2}) ・Plantation and Rice-field Area (Land Cover) (V_{P5})
Sediment disaster	・ Slope (H_{J4}) ・ Geology (H_{J5}) ・ Annual Rainfall (H_{J6})	・Population Density (V_{J1}) ・Built-up Area (V_{J2}) ・Land Cover (V_{J4})	・Slope (H_{P4}) ・Geology (H_{P5}) ・Annual Rainfall (H_{P6})	・Population Density (V_{P1}) ・Built-up Area (V_{P2}) ・Road/Rail in Steep Area (V_{P4})
Earthquake*	(Ground surface acceleration intensity)	(Number of Building by Type for each Kecamatan) (Damage rate)	(Ground surface acceleration intensity)	(Number of Building by Type for each Kecamatan) (Damage rate)
Tsunami disaster	・ Inundation area and depth estimated based on ground elevation (H_{J3})	・Population Density (V_{J1}) ・Built-up Area (V_{J2}) ・Damage Rate (V_{J3})	・Inundation area and depth estimated based on ground elevation (H_{P3})	・Population Density (V_{P1}) ・Built-up Area (V_{P2}) ・Damage Rate (V_{P3})

*: Any types of hazard index and risk index for Earthquake were not estimated. "Ground surface acceleration intensity" was used as seismic hazard map. For assessment of seismic risk, ratio of damaged buildings was made as earthquake risk map based on "Number of buildings by type for each Kecamatan" and "Damage rate".

6 CREATION OF HAZARD MAP

After the preparation of the selected indices, the hazard map can be created. The vulnerability map, consisting of the relevant selected indices, can be also created if necessary.

The hazard map can be created as the summation of the selected indices which are to be selected after the some trial creations of hazard map. It should be noted that the hazard map does not need to be created as the summation of the selected indices. A hazard map can be the result of overlaying the hazard indices. The vulnerability map, consisting of the relevant selected indices, can be also created if necessary.

Hereinafter, the procedures of hazard maps which have been prepared for Kabupaten Padang Pariaman are introduced briefly as example case as well as maps for vulnerability.

A. Hazard Map for Flood Disaster

Flood disasters are regarded to be brought down due to the following factors; 1) Climatic factor, 2) Hydro-geographical factor, 3) Socio-economic factor and 4) Countermeasure factor. It is almost impossible to control rainfall amount, which is one of the climatic factor, but the potential flood damage can be reduced by strengthening the countermeasure factor (*e.g.* Construction of levee, Channel improvement, Early warning system, Land use limitation, *etc*.), which may give some beneficially effects to the Hydro-geographical factor and the Socio-economic factor to some extent so that resilient community to flood disaster will be attained.

As for Kabupaten Padang Pariaman, a number of flood events had been observed in the alluvial low-lying area which covers most of the inland up to some 3km to 10km from coastal line in the south part as well as the northwest coastal line. Along 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. Along rivers in mid-reach to upstream (Anai river, Ulakan river, Tapakis river, Mangau river and Piaman river), some flood marks on some houses could be observed, which are located within 0.5km – 1.0km from main stream and relatively flat area.

In consideration of the above, the hazard map and risk map for flood disaster in Kabupaten Padang Pariaman were made based on the data or information derived or provided from the relevant organizations.

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. 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 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.

$$Hazard = H_{P7} + H_{P8} + H_{P7} + H_{P10}$$

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.

a) Flatness (less than 5 degree in slope)

Flat land which is less than 5 degree in slope can be regarded as “flood plain/flood prone area” from hydro-geographical point of view, then a scoring system to assess hazard in terms of flatness is applied based on the following classification.

i) Score 3 : Flat land less than 5 degree in slope

ii) Score 0 : Others

Figure 5 shows the score distribution of the hazard index “Flatness” based on the above classification with the use of the slope map (SRTM) indicated in Figure 6. As shown in the map, most of the south part of Kabupaten Padang Pariaman is assessed as flat area except mountainous area covering Kec. 2x11 Kayu Tanam, Kec. Lubuk Alung and Kec. Batang Anai. And, most of the inland up to some 5km from coastal line is also assessed as flat area in the north part of Kabupaten Padang Pariaman covering Kec. Batang Gasan and Kec. Sungai Limau.

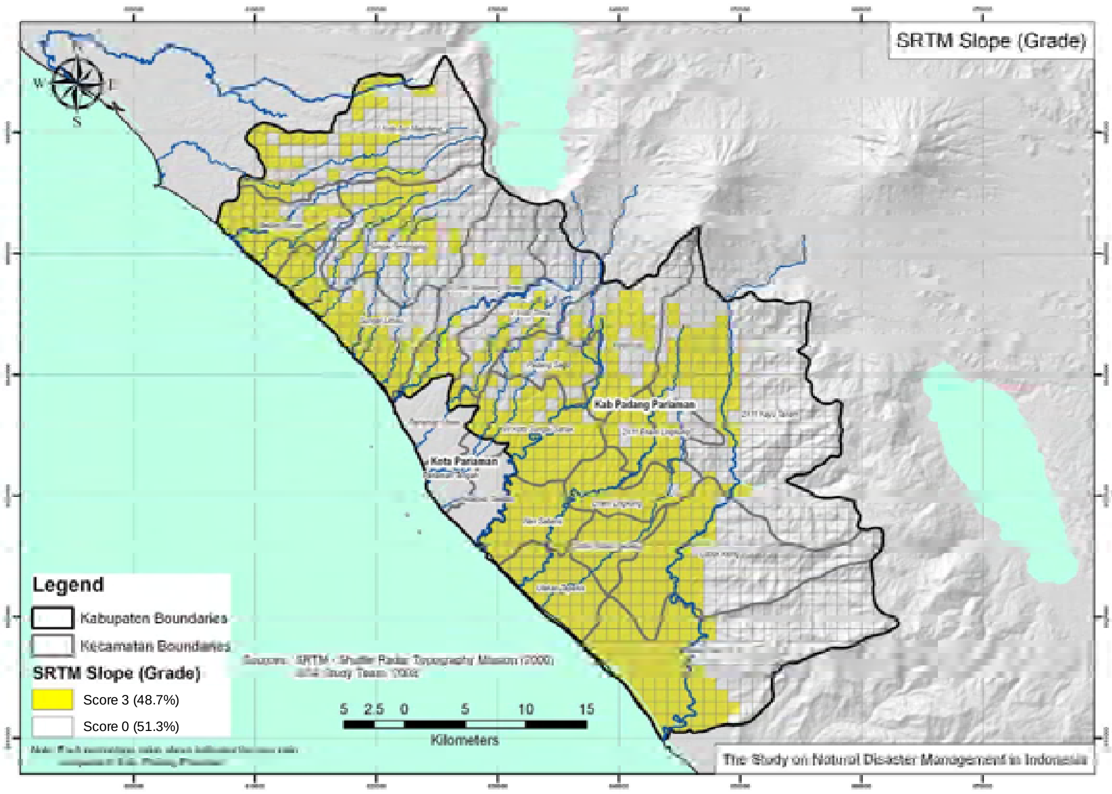


Figure 5 **Hazard Index Map "Flatness"**

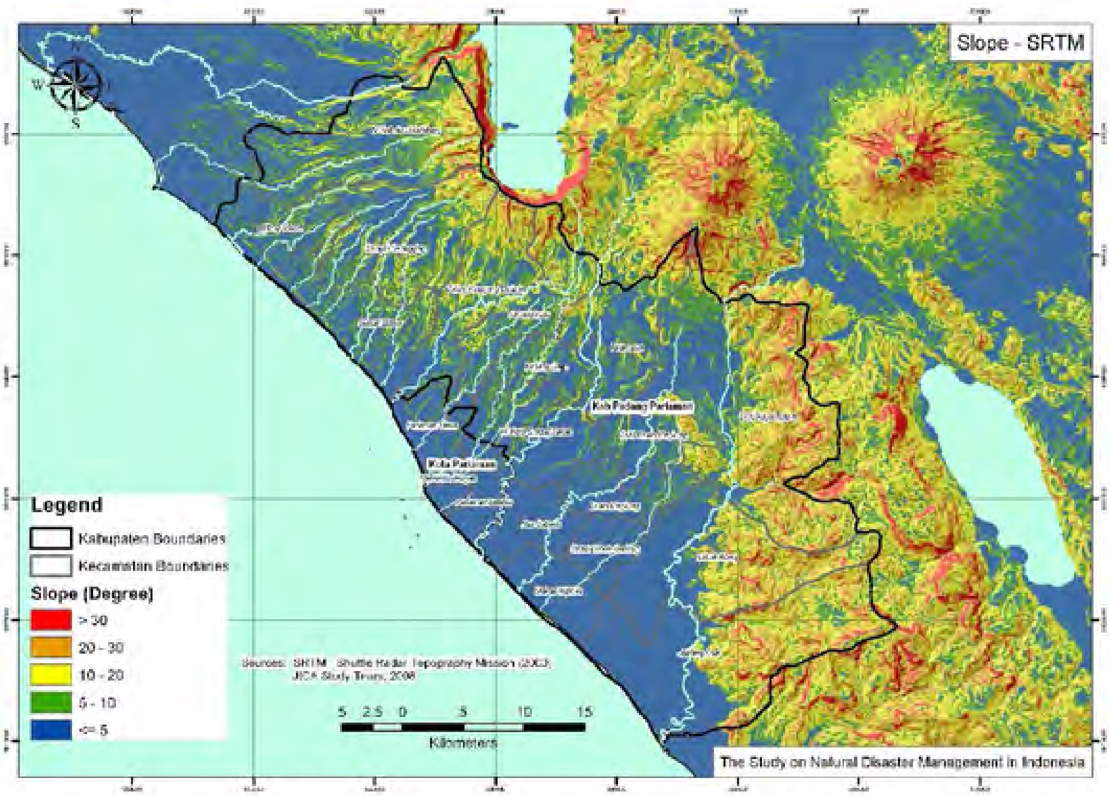


Figure 6 **Slope Map based on DEM (SRTM) in Kabupaten Padang Pariaman**

b) Alluvium land (based on geology map)

"Alluvium land", in short, means the area where river flow triggers sediment erosion, transportation and deposition actions. It may imply the flood potential extent. Then, Alluvium land can be regarded as a part of flood hazard, then a scoring system to assess hazard in terms of alluvium is applied based on the following classification.

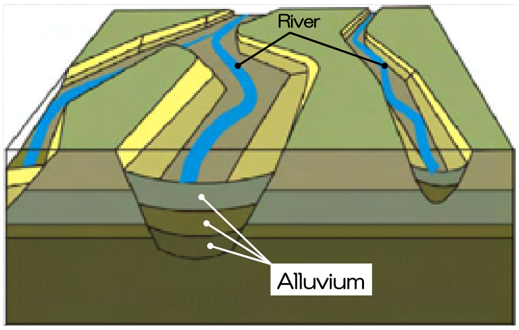


Figure 7 Alluvium land

i) Score 3: Alluvium land

ii) Score 0: Others

Figure 8 shows the score distribution of the hazard index "Alluvium land" based on the above classification with the use of geology map indicated in Figure 9. The map indicates that most of the inland up to some 3km to 10km from coastal line is assessed as alluvium land in the south part of Kabupaten Padang Pariaman. Some of the areas along rivers also are assessed as alluvium land.

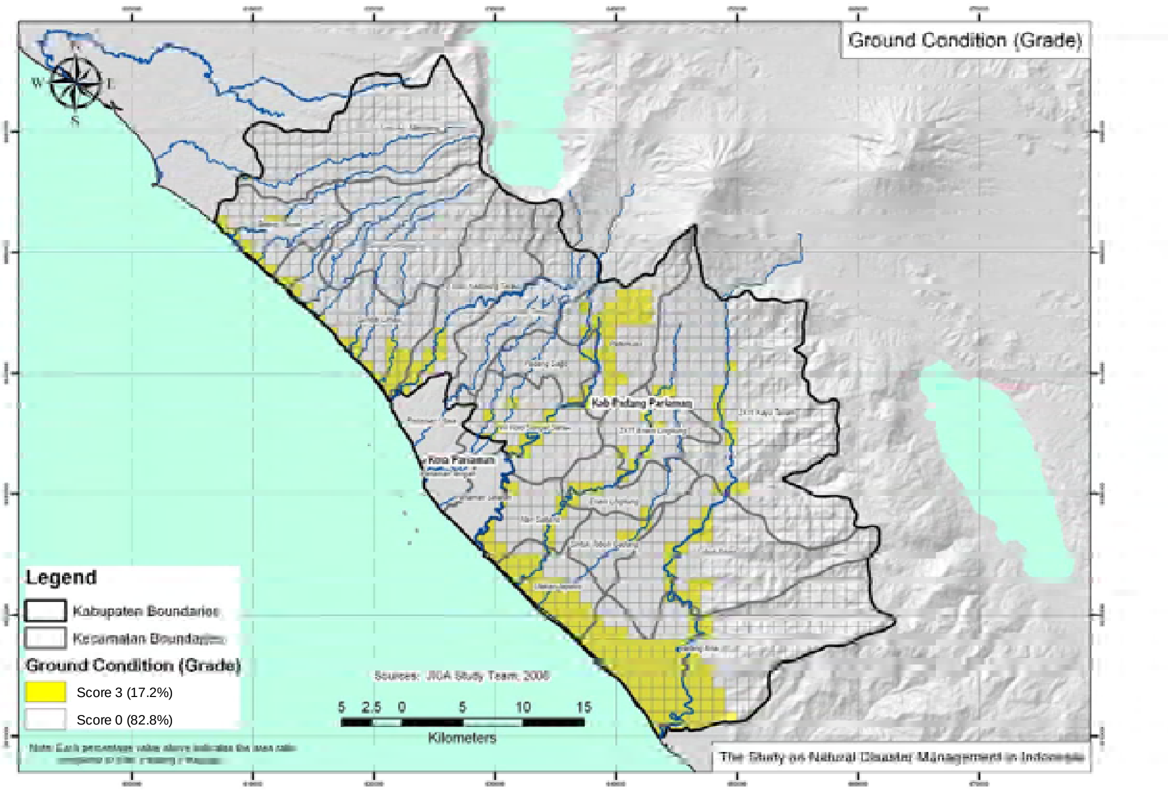


Figure 8 Hazard Index Map "Alluvium land"

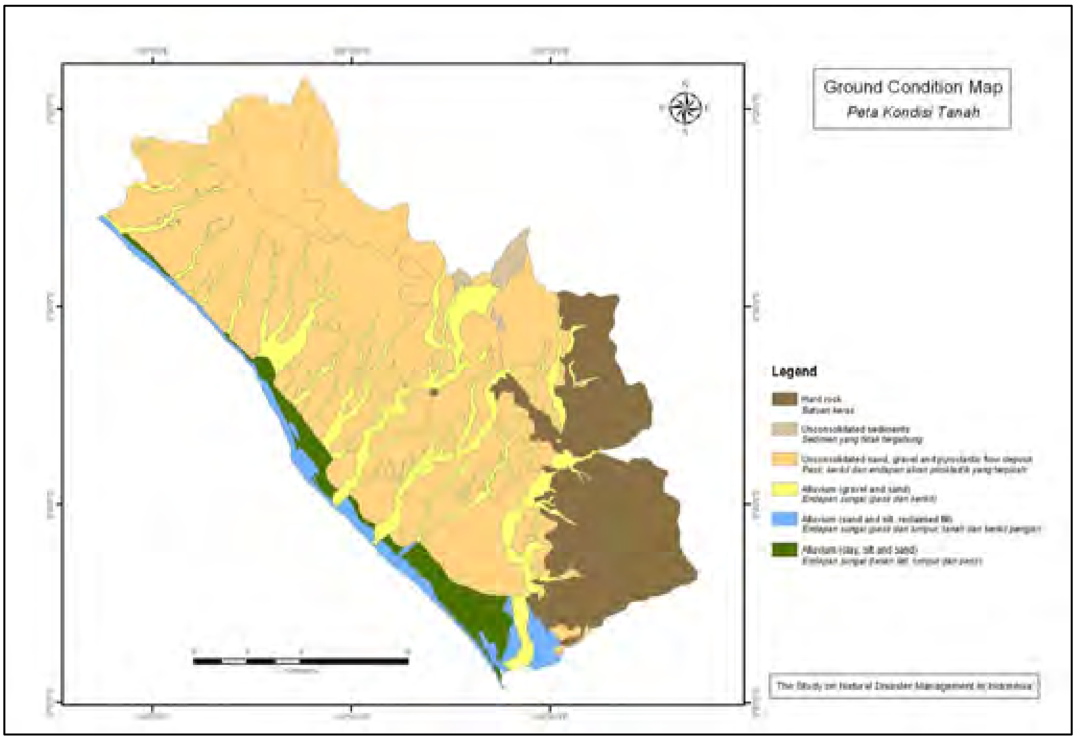


Figure 9　　　Ground Condition Map (Geology)

c) Flood Depth

It is possible to comprehend flood potential area roughly with the above hazard index maps: “Flatness” and “Alluvium land”. On the other hand, the recent flood area may indicate more realistic flood hazard area. Since the past flood disaster area including flood depth and flood duration for the year of 2003 to 2007 was provided by PSDA of West Sumatra Province, “Flood Depth” is adopted as one of flood hazard indices. Scoring system to assess hazard in terms of flood depth is applied based on the following classification, since deeper flood depth may cause large damage to assets, livelihood and economic activities.

i)	Score 5	: 300cm or more	<Highest Hazard>
ii)	Score 4	: 200cm to 299cm	<Higher Hazard>
iii)	Score 3	: 100cm to 199cm	<Moderate Hazard>
iv)	Score 2	: 50cm to 99cm	<Lower Hazard>
v)	Score 1	: 20cm to 49cm	<Lowest Hazard>
vi)	Score 0	: less than 20cm	<No Hazard>

Figure 10 shows the score distribution of the hazard index “Flood Depth” based on the above classification with the use of the past flood disaster area from the year of 2003 to 2007, which was provided by PSDA of West Sumatra Province (Figure 11).

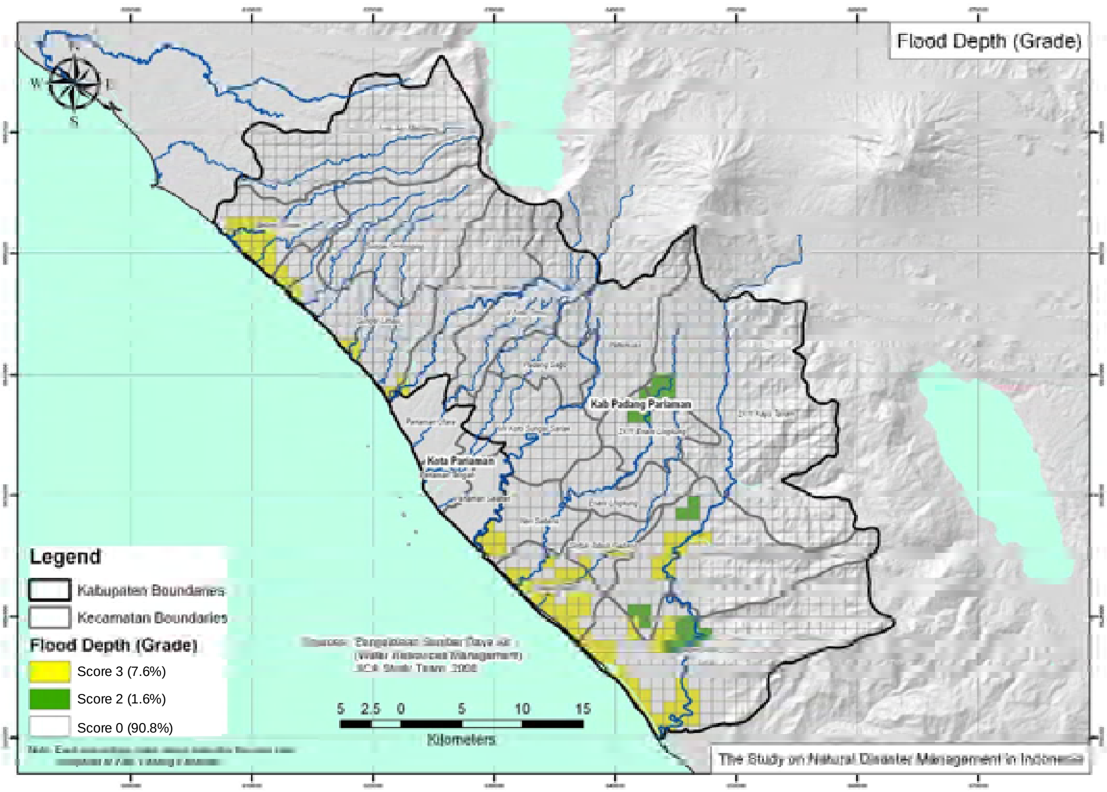


Figure 10 Hazard Index Map "Flood Depth"

Source: PSDA (Pengelolaan Sumber Daya Air), West Sumatra Province

Figure 11 Past Flood Disaster Area (2003 - 2007)

d) Flood Duration

Since the past flood disaster area including flood depth and flood duration for the year of 2003 to 2007 was provided by PSDA of West Sumatra Province, "Flood Duration" is adopted as one of flood hazard indices. Scoring system to assess hazard in terms of flood duration is applied based on the following classification, since longer flood duration may cause large damage to assets, livelihood and economic activities.

i)	Score 5	: 7days or more	<Highest Hazard>
ii)	Score 4	: 5 to 6 days	<Higher Hazard>
iii)	Score 3	: 3 to 4 days	<Moderate Hazard>
iv)	Score 2	: 1 to 2 days	<Lower Hazard>
v)	Score 1	: 1 to 24 hours	<Lowest Hazard>
vi)	Score 0	: less than 1 hour	<No Hazard>

Figure 12 shows the score distribution of the hazard index "Flood Duration" based on the above classification with the use of the past flood disaster area from the year of 2003 to 2007, which was provided by PSDA of West Sumatra Province (Figure 11).

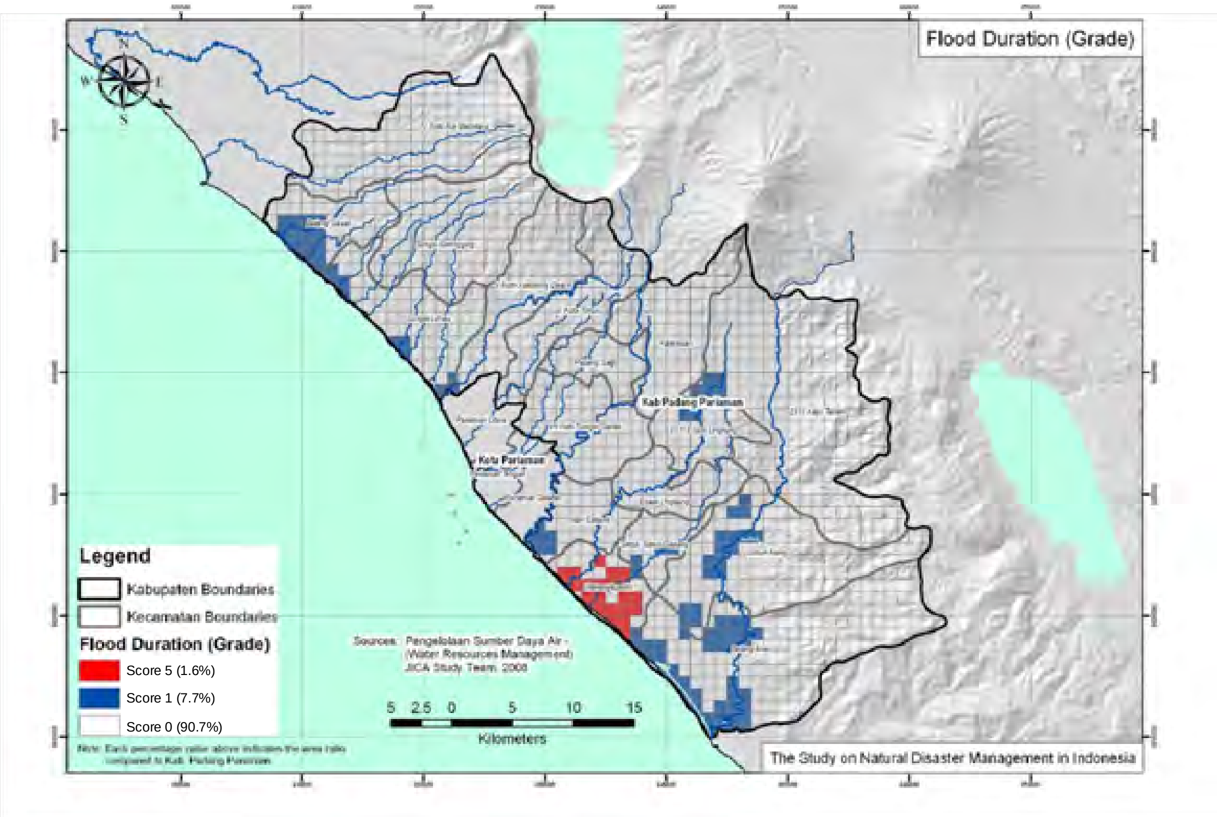


Figure 12 Hazard Index Map "Flood Duration"

e) Hazard Map for Flood Disaster

Refer to Figure 13 shows the flood hazard map for Kabupaten Padang Pariaman based on the formula (Hazard = $H_{P7} + H_{P8} + H_{P7} + H_{P10}$). 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.

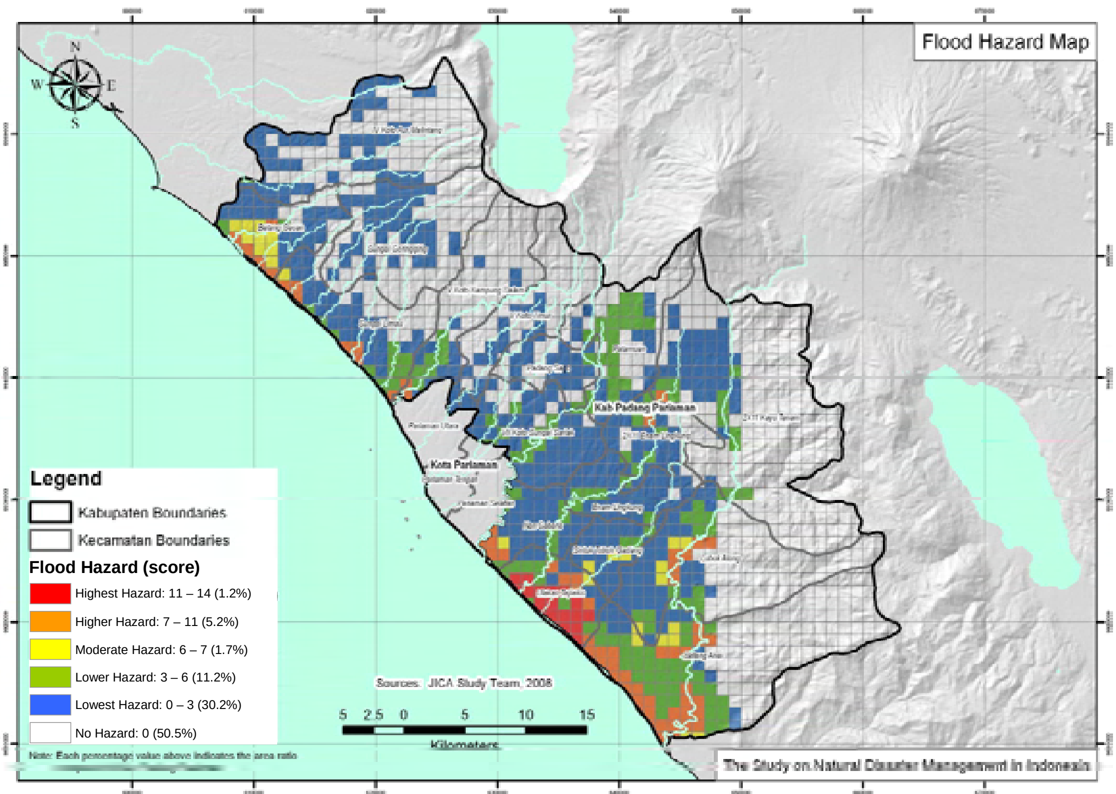


Figure 13 Flood Hazard Map for Kabupaten Padang Pariaman

B. Hazard Map for Sediment Disaster

Based on data collected from related institutions and the main factors of those shown to have triggered sediment disasters in other studies, there are two primary causes for sediment disaster: mechanical factors and incitant factors. Mechanical factors depend on the field conditions where a sediment disaster takes place, whereas an incitant factor is an external force which affects the area where a sediment disaster takes place. The mechanical and incitant factors of sediment disaster are summarized in the table below.

Table 4 Mechanical and Incitant Factors of Sediment Disasters

SEDIMENT DISASTER	MECHANICAL FACTORS	INCITANT FACTORS
Slope Failure	Geology: impact of rock strength, weathering, deterioration, cracks / fractures, direction of terrain, condition of permeable layer, looseness of surface layer, layer distribution. Features: most slope failure on steep slopes (30 degrees or more), as well as recessed slopes where rainfall can accumulate and change the shape of the slope. Vegetation: forest recognized for effect to prevent surface failure.	Rainfall: many cases of slope failure where there is intense rainfall and already moisture in the ground. Seismic/Volcanic activity: earthquakes and volcanic activity affects stress conditions inside the slope, destabilizing the ground. Groundwater: Water seepage from rain can increase water pressure in the soil and impact slope failure. Human activity: deforestation, changing the natural slope by earth cutting or filling, etc.
Debris flow	Basin geography: steep slopes, unstable mountainside, potential for surface water to accumulate, existence of groundwater or springs. River geography: vertical slope in river bed, planar and vertical grade of river channel. Unstable soil: thickness of weathered hill slope layers, thickness and amount of river bed sediment, volume and composition of sediment, sedimentation due to slope failure.	Rainfall/Snow Melt: Rapid increase of water flow or great quantity of runoff. Seismic/Volcanic activity: large amount of unstable soil produced from slope failure (mechanical), collapse of crater lake from eruption, runoff of heavy snow melt, etc.
Landslide	The greatest incidence of landslides is of the tertiary layer. The tertiary sediment layer is young with low solidity so there is little resistance to weathering. Also, the mode of weathering has characteristics, as repeated alternation between dry and wet will refine the grain or create rapid argillation. Further, the ground is composed of sandstone / mudstone, and smectite (montmorillonite) contained in the mudstone has the potential to swell, which can trigger a landslide.	Water will incite landslides. This mainly happens when rain water permeates the ground. When that water increases pressure in the pores of the soil, this decreases the soil shearing force. On the other hand, landslides can also be triggered by human activities such as cutting away the slope in the landslide zone, or even cutting or filling land in an area seemingly unrelated to the landslide zone for civil engineering purposes.

Source: GUIDELINES FOR DEVELOPMENT OF WARNING AND EVACUATION SYSTEM AGAINST SEDIMENT DISASTERSIN DEVELOPING COUNTRIES (Infrastructure Development Institute-Japan)

The hazard map for sediment disasters 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 creating the hazard map for sediment disasters are indicated in Table 5. The indices of “Slope”, “Geology” and “Annual Rainfall” were adopted as indices of sediment hazard.

Table 5 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.

$$Hazard = H_{P4} + H_{P5} + H_{P6}$$

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

a) Slope

As mentioned above, many cases of sediment disaster involve slope incline as a mechanical factor. Generally, landslips take place on gentle 5 to 30 degree slopes, whereas larger landslides take place on steep inclines over 30 degrees. In addition, in Kabupaten Padang Pariaman, trying to view landslide configuration by using a field survey or aerial photograph was not acceptable. Based on this knowledge, SPOT data (20m resolution) and SRTM (90m resolution) data are used, and the hazard index map “slope” was created. The original SPOT data doesn’t cover the entire area of Kabupaten Padang Pariaman. So SRTM data, which covers the entire area, was used to interpolate the blank grid of SPOT data. A scoring system to assess hazard in terms of slope is applied based on the following classification.

i) Score 5 : 30^{o} or more <Highest Hazard>
ii) Score 4 : 20^{o} - 30^{o} <Higher Hazard>
iii) Score 3 : 10^{o} - 20^{o} <Moderate Hazard>
iv) Score 2 : 2^{o} - 10^{o} <Lower Hazard>
v) Score 1 : 2^{o} or less <Lowest Hazard>

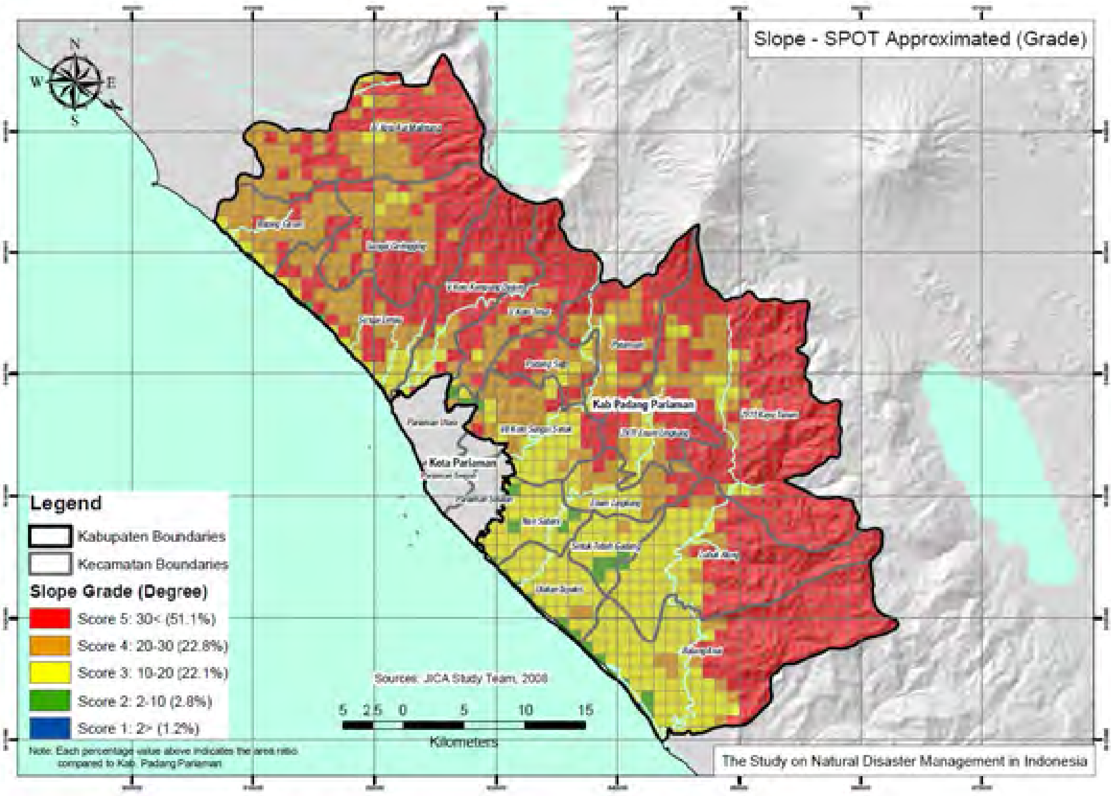
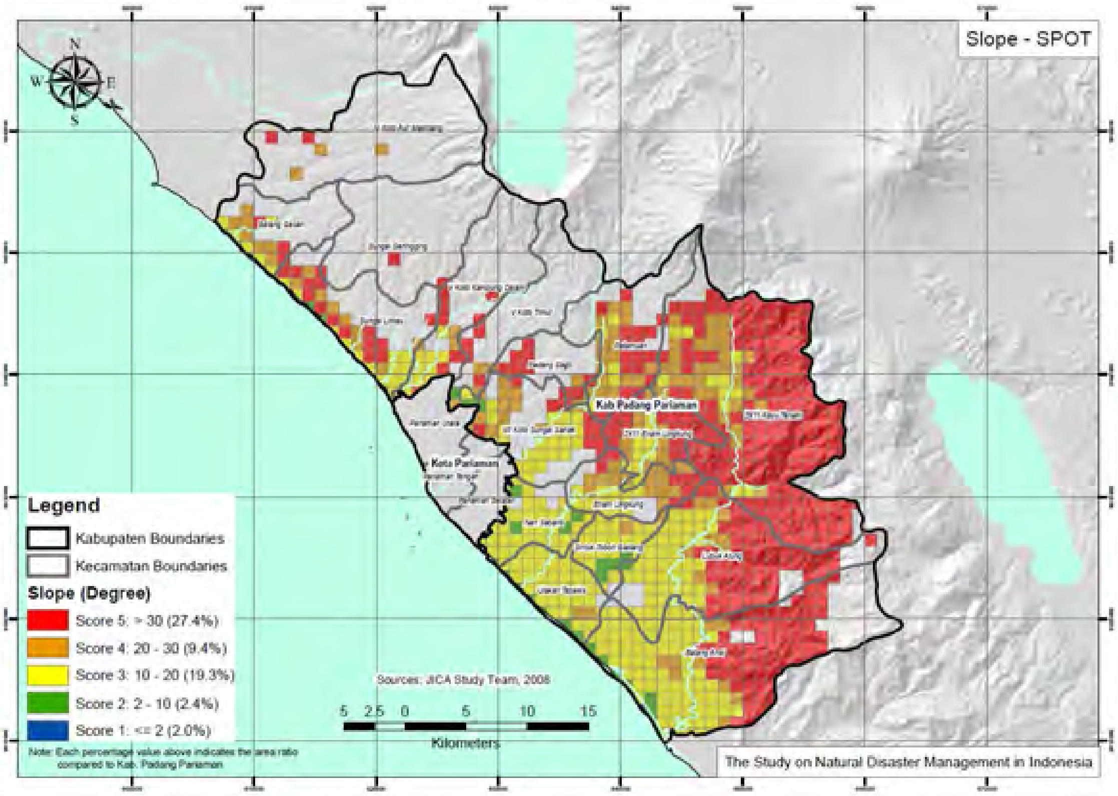
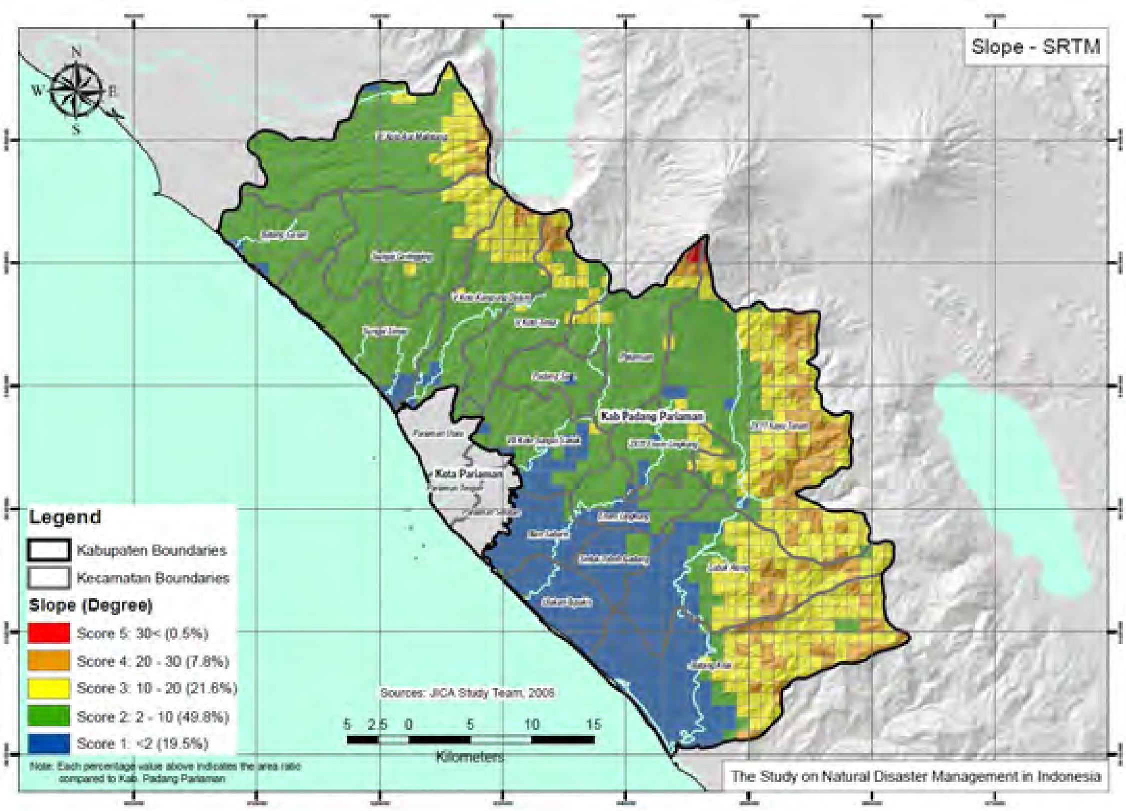


Figure 14 Hazard Index Map "Slope (H_{P4})"



Note: The gray area is where SPOT data is missing.

Figure 15 Slope Classification Map using original SPOT Data



Note: SRTM data covers the entire area of Kabupaten Padang Pariaman and was used to interpolate the blank grid of SPOT data.

Figure 16 Slope Classification Map using SRTM Data

b) Geology

Geology is a significant mechanical factor in sediment disaster. A geology map was made based on analysis that specifies which conditions are prone to disaster. Fundamentally, the hazard area can be termed as the area in which unconsolidated sediments, unconsolidated sand, gravel and what is called pyroclastic flow sediments, such as pyroclastic flow deposit, are located. Scoring system to assess hazard in terms of geology is applied based on the following classification.

i) Score 5 : Unconsolidated sediments, unconsolidated sand, gravel and pyroclastic flow deposit <Highest Hazard>

ii) Score 3 : Hard rock, alluvium (gravel and sand) <Moderate Hazard>

iii) Score 1 : Alluvium (sand and silt, reclaimed filler) <Lowest Hazard>

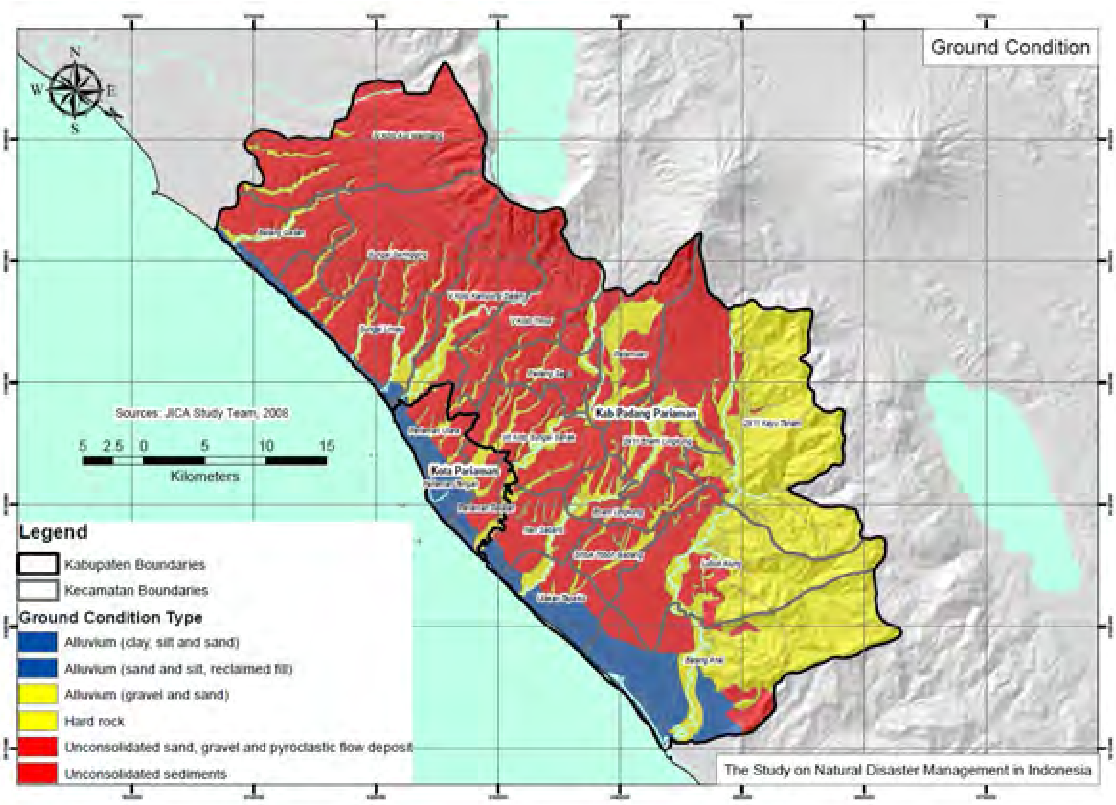


Figure 17 Geology Map (same as Figure 9)

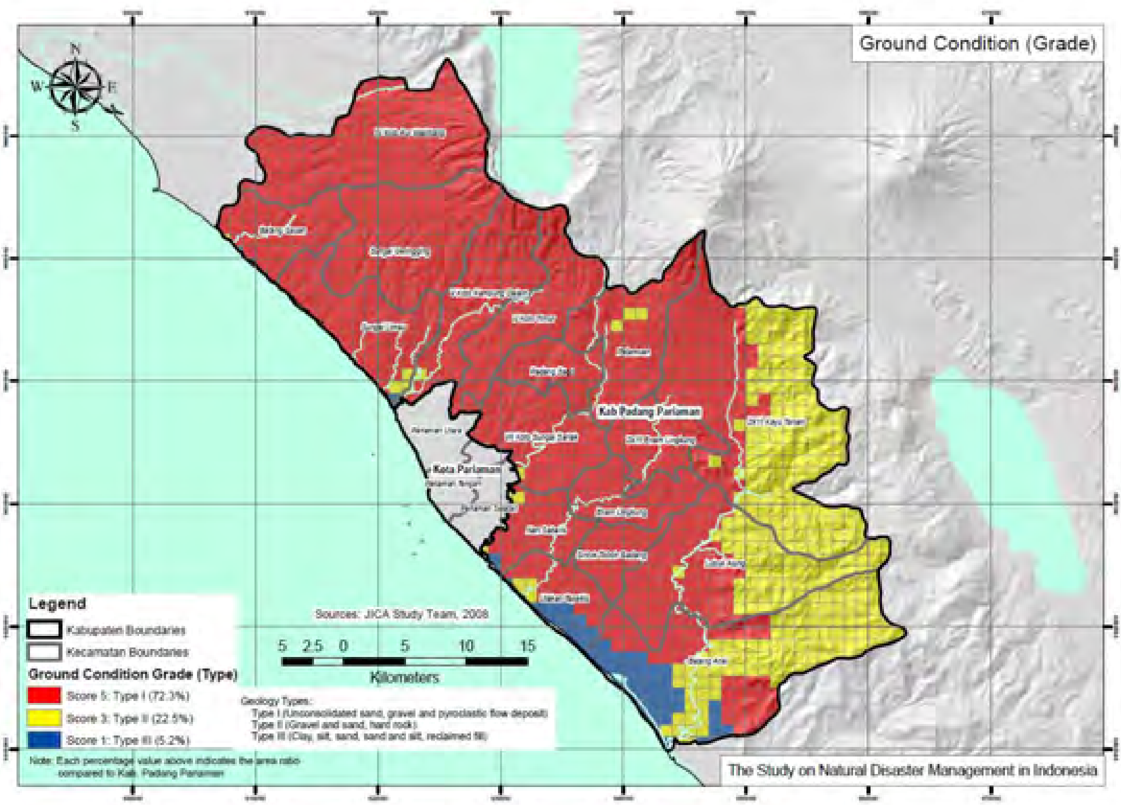


Figure 18 Hazard Index Map "Geology (H_{P5})"

c) Annual Rainfall

Precipitation is a large incitant factor of sediment disasters. The data currently observed in Kabupaten Padang Pariaman and its vicinity was collected. The average annual rainfall data are used as an index. The annual rainfall was divided into five categories and scored accordingly, as follows:

i)	Score 5	: 4,500 - 5,000 (mm)	<Highest Hazard>
ii)	Score 4	: 3,500 - 4,500 (mm)	<Higher Hazard>
iii)	Score 3	: 2,500 - 3,500 (mm)	<Moderate Hazard>
iv)	Score 2	: 1,500 - 2,500 (mm)	<Lower Hazard>
v)	Score 1	: 1,000 - 1,500 (mm)	<Lowest Hazard>

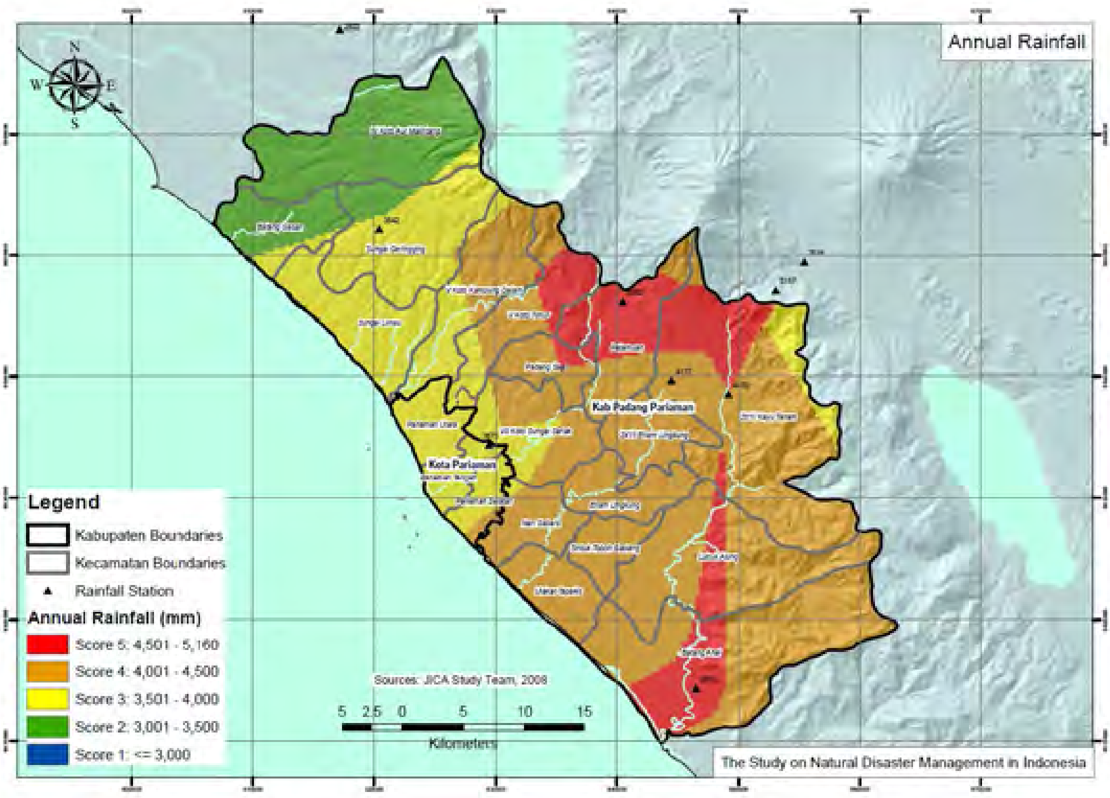


Figure 19 Annual Rainfall Distribution Map

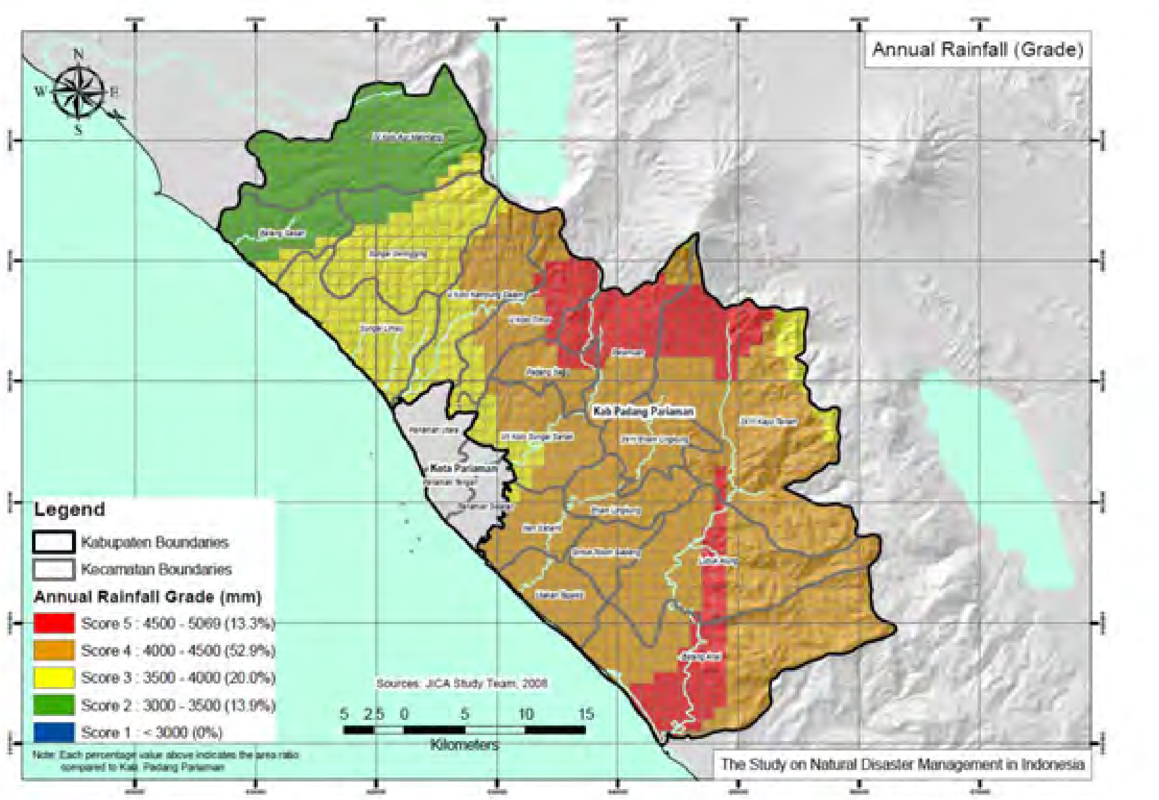


Figure 20 Hazard Index Map "Annual Rainfall (H_{P6})"

d) Hazard Map for Sediment Disaster

Refer to Figure 21 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 hazard classification. Kabupaten Padang Pariaman is widely covered by friable pyroclastic products except the coastal plains in the 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. In particular, 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 areas of high hazard.

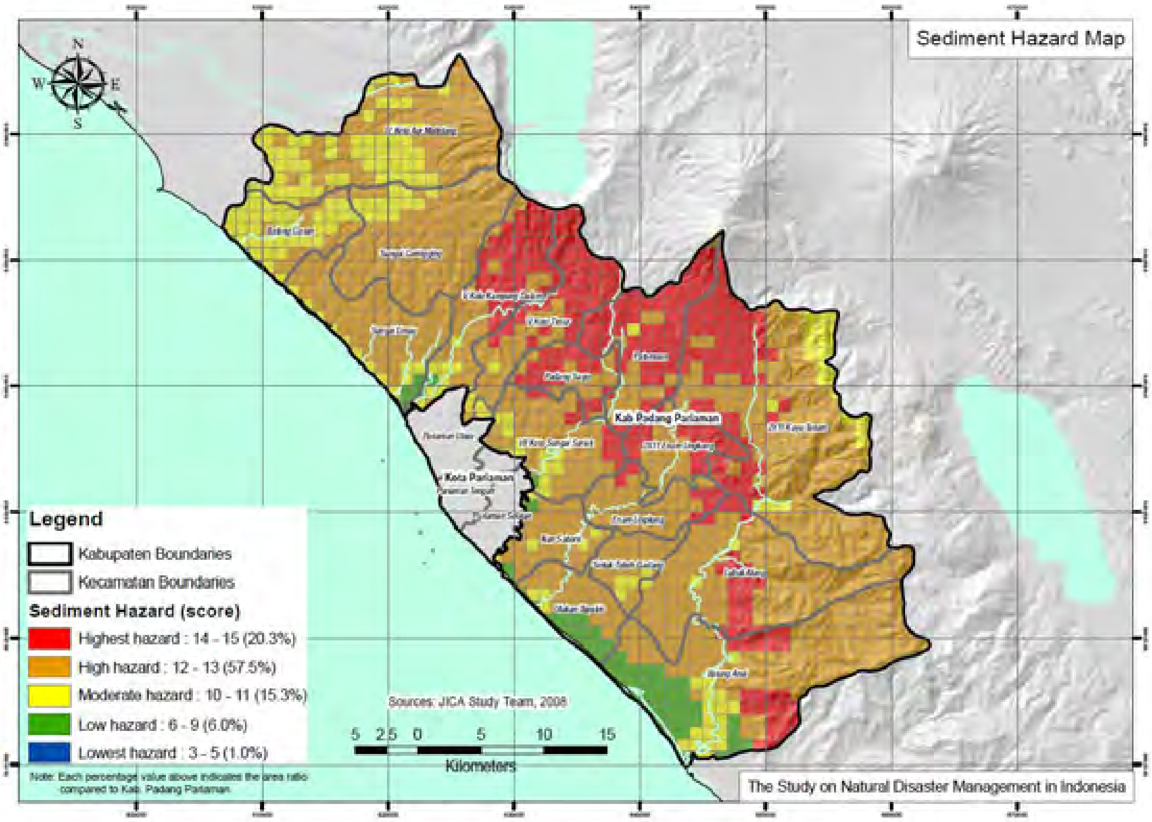


Figure 21 Sediment Hazard Map for Kabupaten Padang Pariaman

C. Hazard Map for Earthquake

a) Basis of Hazard Map Creation for Earthquake

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". No other aspect is necessary for Hazard Map for the above definition. The ground surface acceleration intensity is described at each part of mesh in study area using the title of "Peak Ground Acceleration" (it is called as PGA here in after) or "Modified Mercalli Intensity scale" (it is called as MMI here in after). Next topic, which is discussed in this chapter, is how to define the target value of the ground surface acceleration intensity. Generally there is a steady tendency of the relationship between the magnitude of earthquake and frequency of occurrence. So this means that small earthquake can occur frequently, but large earthquake rarely occur so frequently.

Figure 22 shows the relationship between the magnitude of earthquake and frequency of occurrence regarding earthquakes that occurred from 1629 to 2004 in Indonesia.

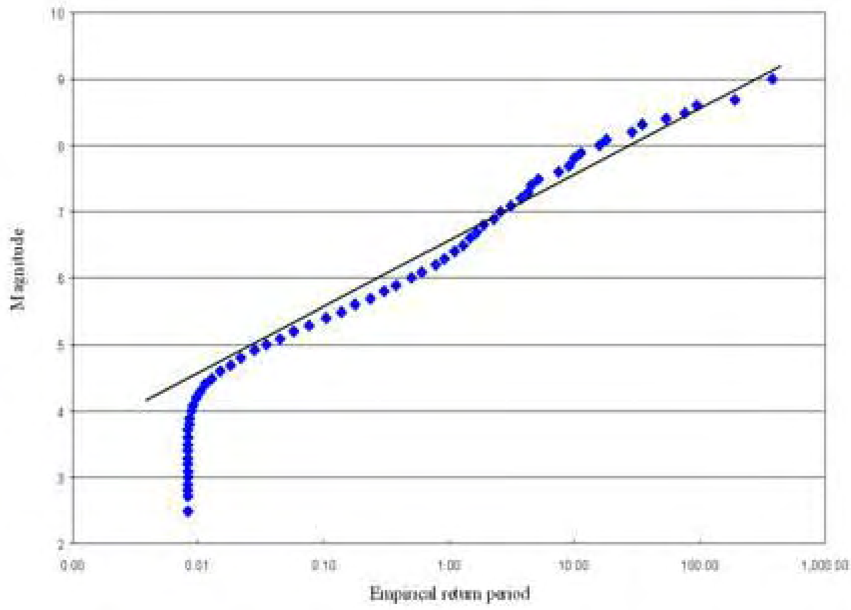


Figure 22 Relation between Magnitude and Return Period

Y axis means magnitude of the earthquake, and X axis means empirical return period T_E。

$$T_E = \frac{T_S}{m}$$

Where

T_E : Empirical return period

T_S : Sampling term

m : Order when the sample is arranged in magnitude order

For example, the largest earthquake generated in this area is the 2004 earthquake with magnitude 9, then order m is the first, Sampling term T_S is 2004 minas 1629 equal to 375, Empirical return period T_E must be 375 years. The large one in second is the 1833 earthquake with magnitude 8.7, then order m is the second, Sampling term T_S is 375 years divided 2 equal to 187, Empirical return period T_E must be 187 years. When the relationship between magnitude and the empirical return period T_E of each recorded earthquake is plotted in the same manner, the plotted pattern tends to be almost on straight line on one-half of logarithm graph paper, but limited in range of more than magnitude 5. This finding is called the thesis of Gutenberg Richiter or G-R formula. The angle b of this approximation line represents the difference between the occurrence frequency of big earthquake and that of small earthquake. If the surrounding of Indonesia is divided into some domains, which has consistent condition of seismicity, the above mentioned angle b must be particular for each particular domain. If the occurrence of earthquakes is a spatially independent and independent time wise incident Poisson model can be applied to the analysis.

The peak acceleration value of the base rock at a certain point can be calculated utilizing attenuation formula. Attenuation formula is a kind of regression formula by which the peak acceleration value of the base rock is presumed from the magnitude of earthquake source and distance from earthquake source to a certain point.

In this computational procedure previously mentioned each domain must be further divided into small piece by utilizing polar coordinate system. In addition, an implicit method is needed in this procedure because the magnitude of earthquake source, which brings the peak acceleration value in a certain point, must be obtained at a computation step. Therefore a huge amount of the calculation is required in order to carry out this analysis. The computer program "EZFRISK" or “EQRISK” is used in an actual analysis. The peak acceleration value of the base rock at each part of Indonesia was calculated. Figure 23 shows the results of the above described procedure.

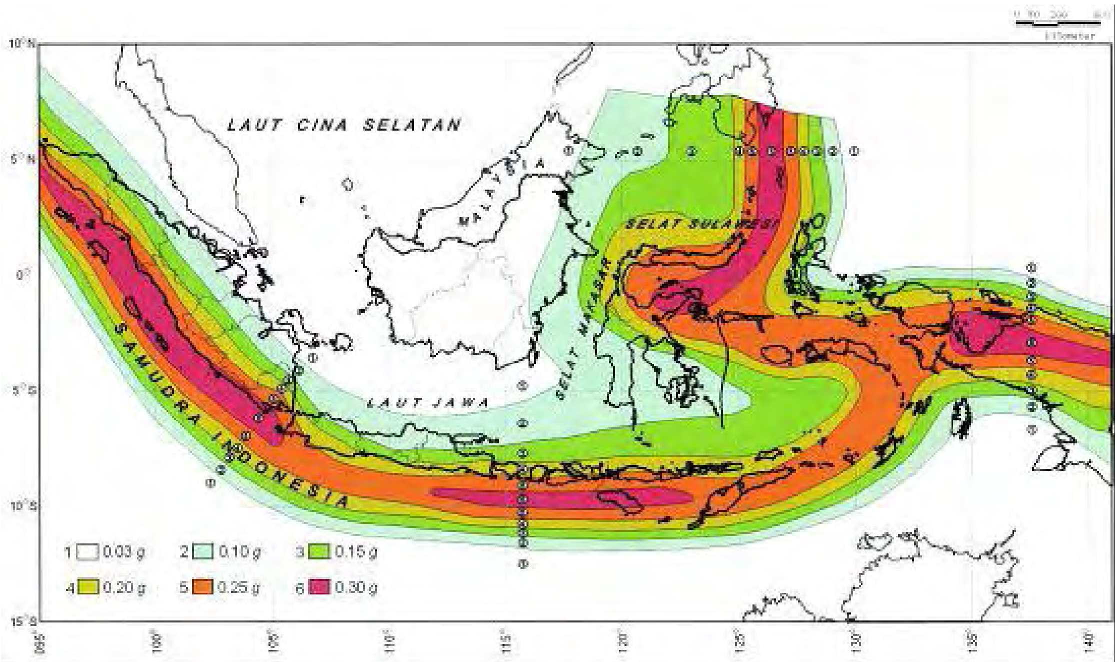


Figure 23 Peak Acceleration Value of the Base Rock at Each Part of Indonesia (From SNI 03-1726-2002 the Indonesian code for seismic load)

Each value shown in Figure 23 is the peak acceleration value of the base rock at each colored zone and corresponding 500 years of return period. For instance, almost part of Kabupaten Padang Pariaman belongs to Zone 5. Therefore the peak acceleration value of the base rock is 0.25g (the value of 0.25g means 0.25 times acceleration of gravity). Detail of zone around study area is shown in Figure 24.

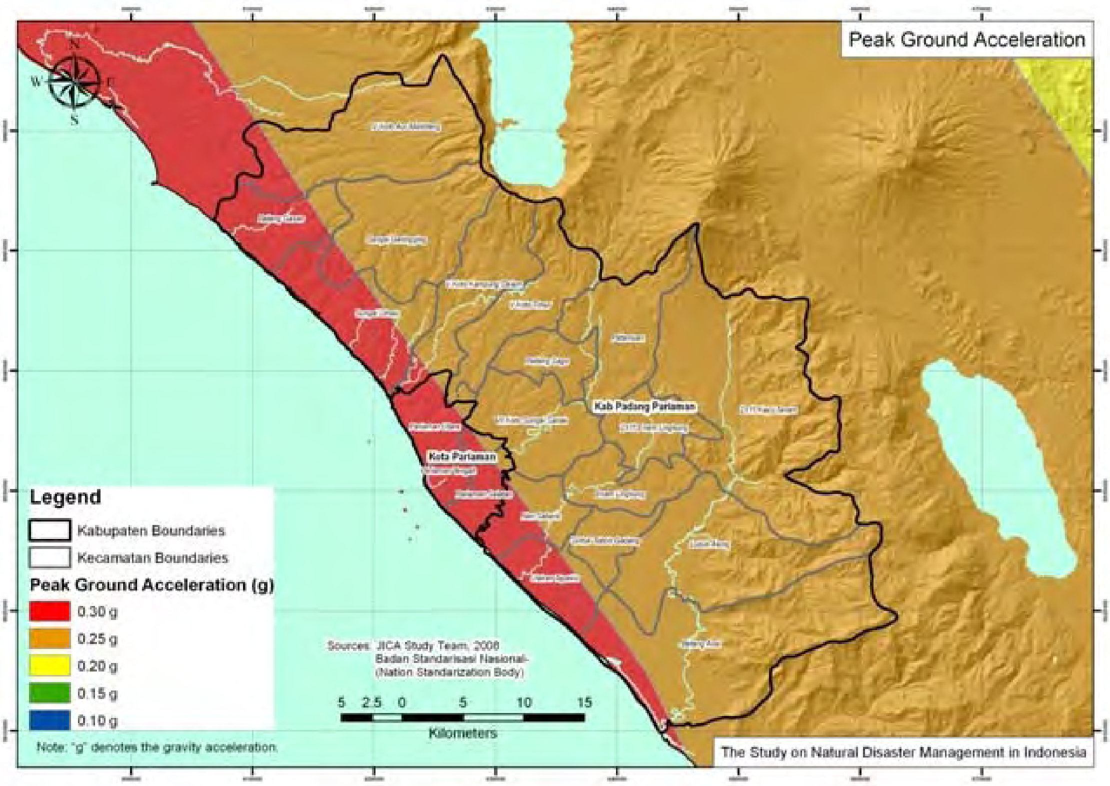


Figure 24 PGA Ground Acceleration

When concretely explaining the 500 years of return period it means that the probability of exceedance is 10% for 50 years. For example, if a structure, which has 50 years of service time, is designed utilizing the design seismic load of 500 years of return period the probability by which the structure will fall due to an unexpectedly large earthquake is 10%. Indeed 90% of incidents are comprised in this category. This setting is almost perfect in realistic meaning because 100% of safety can not be obtained using probability theory.

The above explained value is the peak acceleration value at the base rock that is defined as a base rock layer that is consisted of homogeneous material. The peak acceleration value at the base rock can be estimated utilizing attenuation function. However the value, which is needed for application of hazard map, must be the peak acceleration value at ground surface.

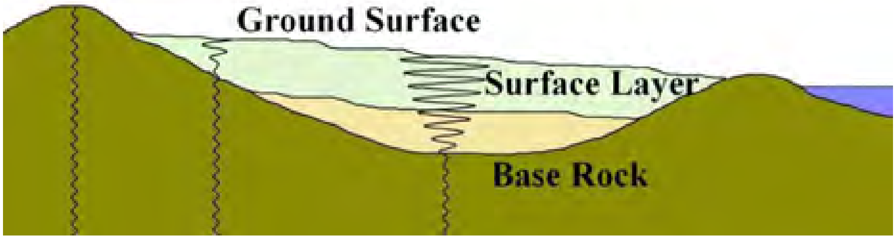


Figure 25 Peak Acceleration Value of the Base Rock and Peak Acceleration Value of Ground Surface

As explained in Figure 25, the ground tremor is amplified while it is propagated in the surface layer. In fact, the ground tremor at outcrop of base rock is usually small. On the other hand the ground tremor at the soft layer is usually large. Degree of amplification depends on characteristics of surface layer of the ground. Surface layer must be investigated in order to discuss this aspect. Geomorphological feature of surface layer around Kabupaten Padang Pariaman is shown in Figure 26.

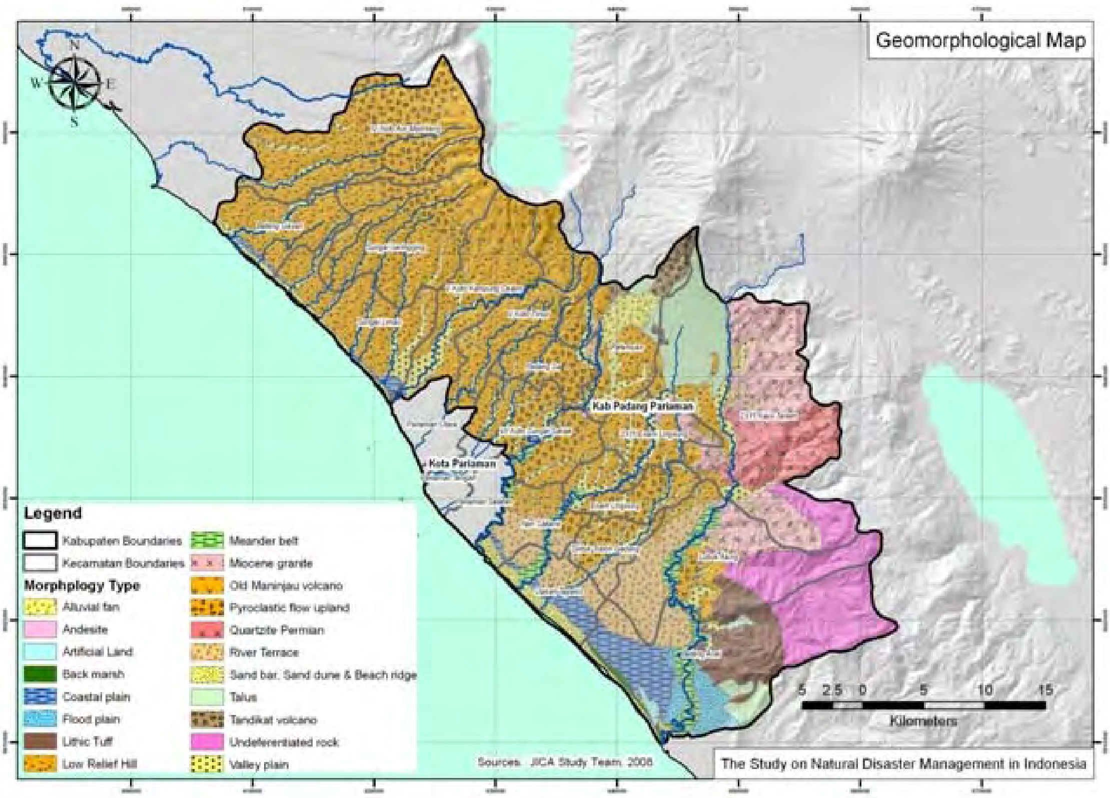


Figure 26 Geomorphological Feature of Surface Layer around Kabupaten Padang Pariaman

Distribution of characteristics of surface layer at each Segment of the study area is shown in Figure 27.

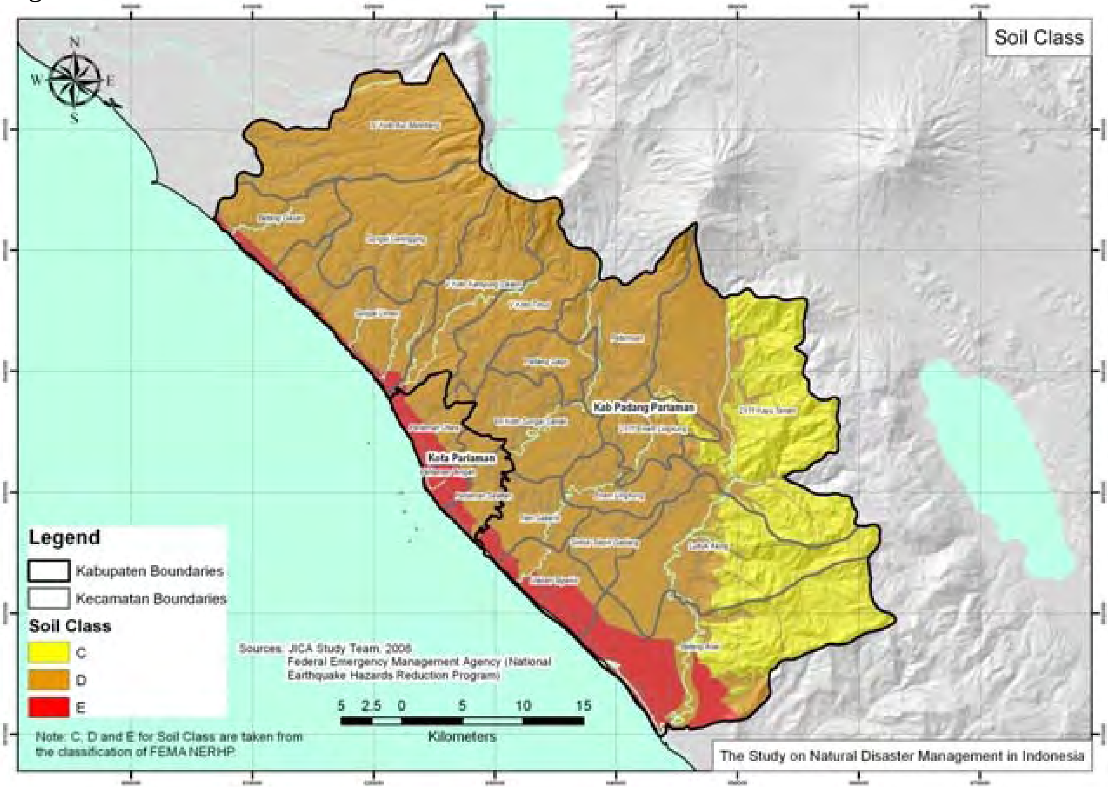
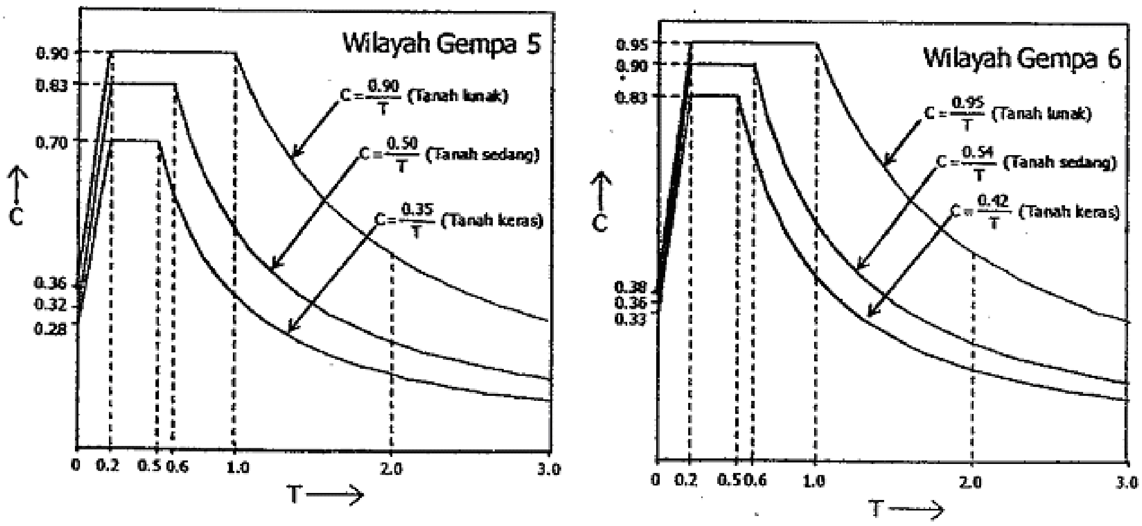


Figure 27 Segmentation of Soil Class (classified according to stiffness of surface layer)

Segmentation of soil class shown in Figure 27 is classified according to stiffness of surface layer. The classification is based on some speculations on geomorphological feature given by geological map and field survey done by the expert in charge of geological features. However more accurate material that will given by borehole logging and PS logging must be referred if it is available. Moreover, continuous improving effort shall be made regarding accuracy of hazard mapping.

As explain here, the intensity of the surface ground motion at earthquake is estimated referring the zone classified in SNI 03-1726-2002 and the soil class. The surface ground motion is expressed by PGA and the response spectrum, shown in Figure 28. The value of vertical axis in the response spectrum means the acceleration response of the SDOF (Single degree of Freedom) model that has the natural period shown in the horizontal axis. Therefore the value on the extreme left correspond to PGA. This value of PGA shall be shown in the hazard map because these values represent the tremor of ground surface.



Zone 5 Zone 6

Figure 28 Response Spectrum Stipulated in 03-1726-2002

b) Earthquake Hazard Map in Kabupaten Padang Pariaman

The expected value distribution of the ground surface acceleration intensity is shown in Figure 29. The ground surface acceleration intensity is described using the title of PGA and MMI. PGA is a value which will be obtained as the maximum value when the quake of the ground level is measured with accelerograph. 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. The estimated MMI for Kabupaten Padang Pariaman is from 8 between 8 or more in the MMI display. This level of intensity corresponds to “5 or more” in Japan Meteorological Agency Seismic Intensity Scale (it is called as JMI hereafter). JMI also divides earthquake intensity into 10 stages of evaluation, and each stage is defined by describing the incident through observation and sensing. Some sort of slight damage is found when the earthquake of “5 or more” in JMI occur in Japan but it is thought that considerably more serious damage may be generated by the same level of earthquake in Indonesia because earthquake resistant capacity of Indonesian buildings is poor comparing with that of Japan.

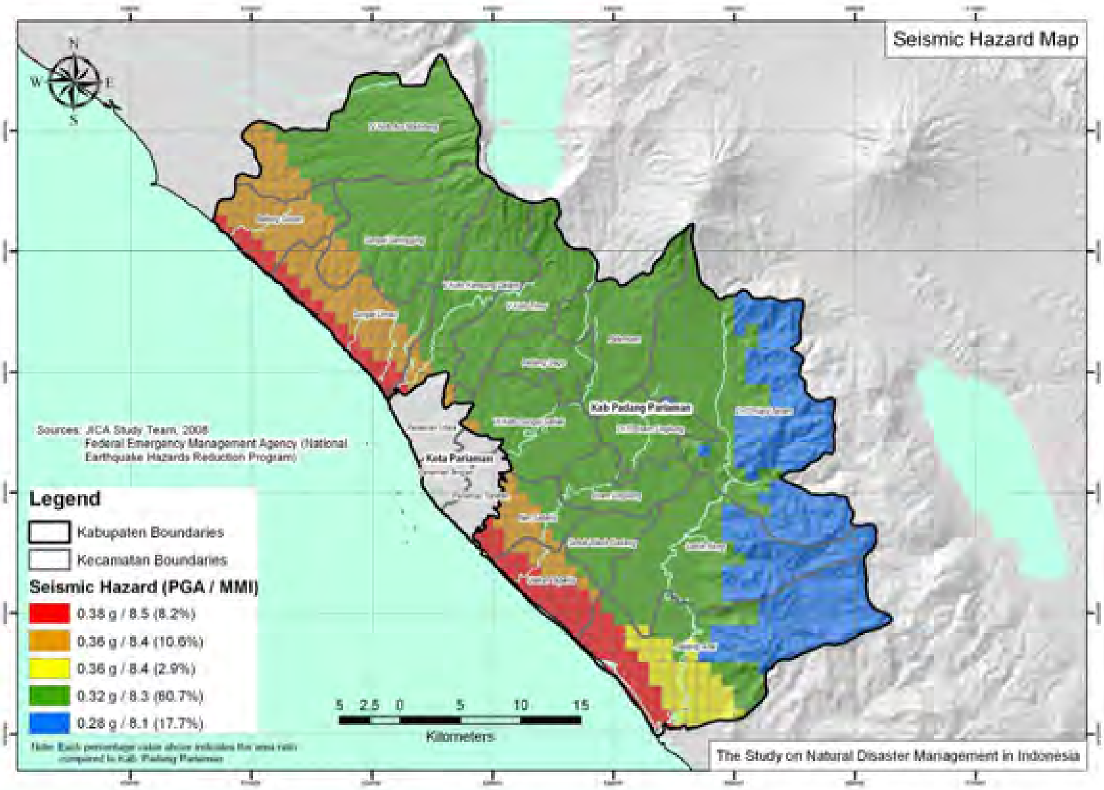


Figure 29 Seismic Hazard Map for Kabupaten Padang Pariaman (Distribution of ground surface acceleration intensity)

D. Hazard Map for Tsunami Disaster

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.

a) Inundation area and depth estimated by level filling method

The water volume intruding form the coast was calculated for 1797 and 1833 tsunamis. The basic data of tsunami was settled based on the records and previous study of numerical simulation of tsunami. They are shown in Table 6 and Figure 30. In addition, the temporal alteration of tsunami was modeled as shown in Figure 31 in order to calculate the water volume overtopping the coast. In this model the wave pattern was approximated by linear regression and the duration time was divided 5 in order to water volume. The calculated amount of the overflow is shown in Table 7.

Table 6 Tsunami Data for Calculating Water Discharge Intruding Inland

Item	Value	Source
Tsunami Height	5.0 (m) above mean sea level	Records of 1797 and 1833 Tsunami in Kota Padang
Period	1,260 (sec)	Some previous results of reconstruction of 1797 and 1833 Tsunami by the numerical simulation
Length of coast line intruded by tsunami	41.8 (km)	Topographical data
Height of sand dune	2.5 (m) above mean sea level	Topographical data and Field survey
Number of the waves overtopping the top of sand dune	3 waves	

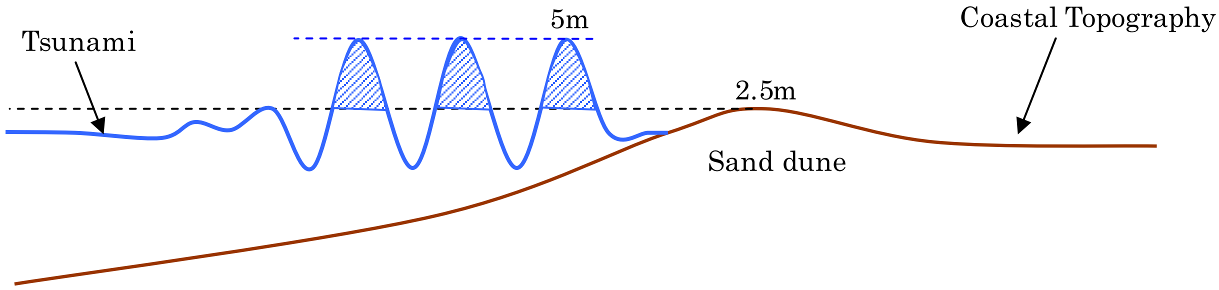


Figure 30 Cross section of Model

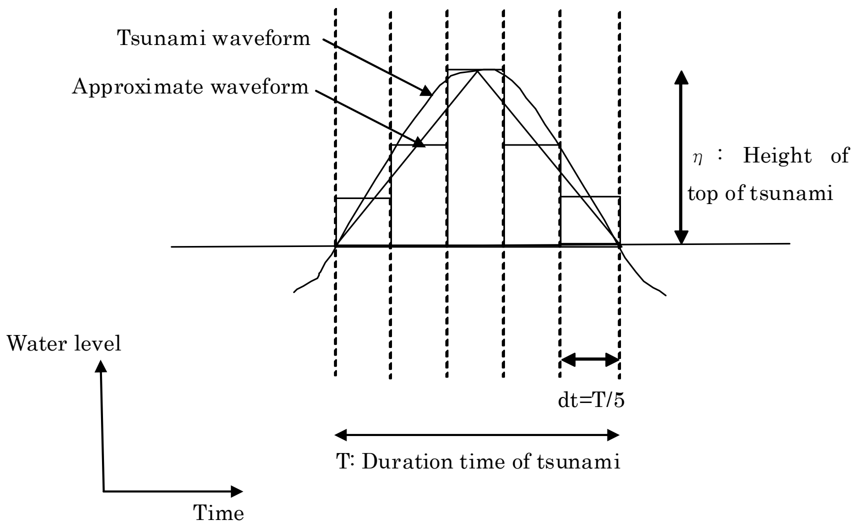


Figure 31 Modeling of Time Waveform

Table 7 Water volume intruding by tsunami

	(A)	(B)	(A)-(B)	(D)	(E)	(D)*(E)
No.	Tsunami Height	Sand dune Height	-	Q1 (m^2/sec)	⊿t (sec)	Q2 (m^2)
1	1.0	2.5	-1.5	0.00	126	0.00
2	3.0	2.5	0.5	0.55	126	69.03
3	5.0	2.5	2.5	6.13	126	771.75
4	3.0	2.5	0.5	0.55	126	69.03
5	1.0	2.5	-1.5	0.00	126	0.00
Summation				(per 1wave and 1m)		909.80
				(per 3wave and 1m)		2729.41

The expected inudation map based on water volume overtopping the coast shown in Table 7 is presented in Figure 32. The grade and the corresponding scores are as follows:

i) 2.0m< (Totally destroyed) ・・・・Score 4
ii) 1.0m<H≤2.0m (Partially destroyed) ・・・・Score 3
iii) 0.5m<H≤1.0m (Flooded above floor level) ・・・・Score 2
iv) 0.0m<H≤0.5m (Flooded below floor level) ・・・・Score 1
v) H=0.0m (No damage) ・・・・Score 0

Level filling method requires a structure or landform that prevents the waves from overtopping it along the coast. However, there are no structures along the coast and the landform such as sand dune doesn't cover all of the coast in Kabuapten Padang Pariaman. Therefore, the expected inundation area might be underestimated at the river mouth where the sand bar is lower than the height (=2.5m) given by the above-mentioned model.

b) Inundation area based on historical inundation records

There were no histrocal record found for the past Tsunami diaster in Kabupaten Padang Pariaman.

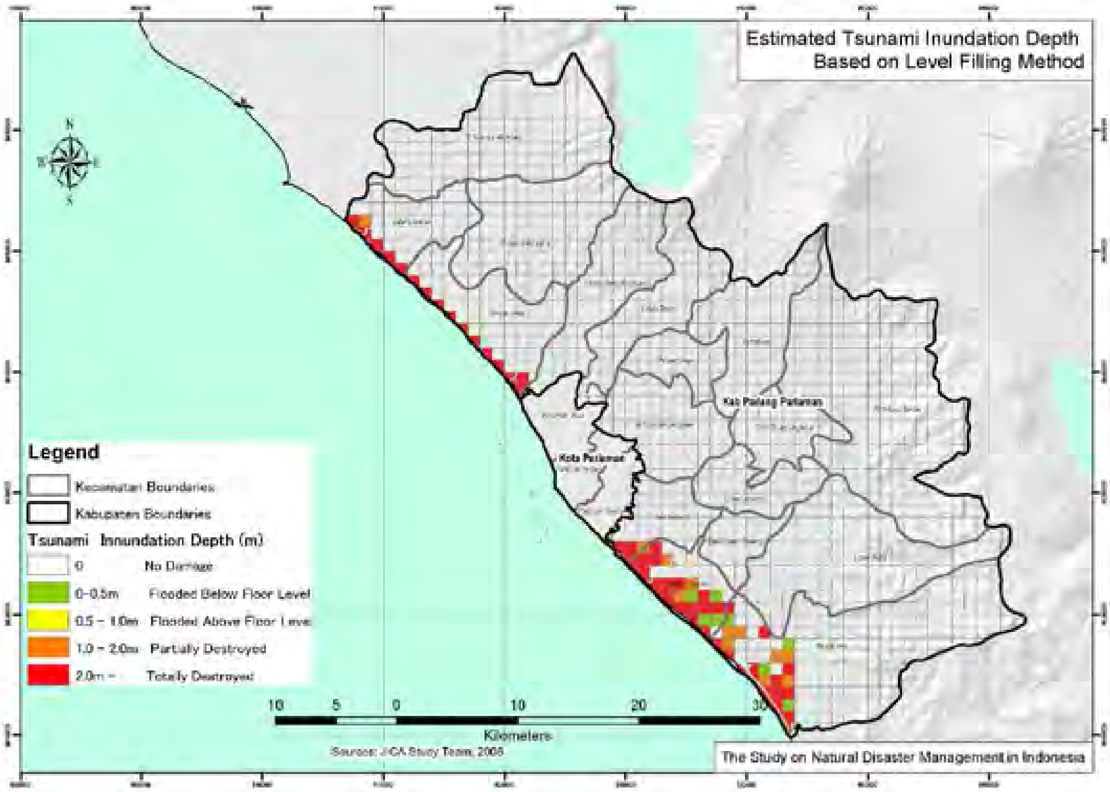


Figure 32 Inundation Area and Depth Estimated by Level Filling Method

c) Inundation area and depth estimated based on ground elevation

Estimation based on ground elevation is comparatively simple method to determine the hazard area and the level based only on the relation between possible tsunami height given by numerical simulation and the ground elevation. The ground elevation data are made from the calibrated SPOT DEM. It is calibrated using the several actual elevations obtained by the leveling which was conducted by Study Team. A SPOT DEM is a digital elevation model produced by automatic correlation of stereopairs acquired by the HRS instrument on SPOT 5, which is the fifth satellite in the SPOT series, placed into orbit by an Ariane launcher. The maximum run-up height of the recurrent earthquake and tsunami in 1797 and 1833 was 5m or less. Therefore, 5m above sea level was set to standard height of the expected tsunami run-up. The grade and the corresponding scores are as follows:

i)	2.0m<	(Totally destroyed)	・・・・Score 4
ii)	1.0m<H≤2.0m	(Partially destroyed)	・・・・Score 3
iii)	0.5m<H≤1.0m	(Flooded above floor level)	・・・・Score 2
iv)	0.0m<H≤0.5m	(Flooded below floor level)	・・・・Score 1
v)	H=0.0m	(No damage)	・・・・Score 0

Compared with the historical tsunami records of Padang in 1833 which describe that the tsunami intruded at least 1km from the coast, the expected tsunami hazard area has extended more than this. Thus the expected tsunami flood area based on ground elevation is judged to be a little overestimated, which is the dangerous side of the estimation.

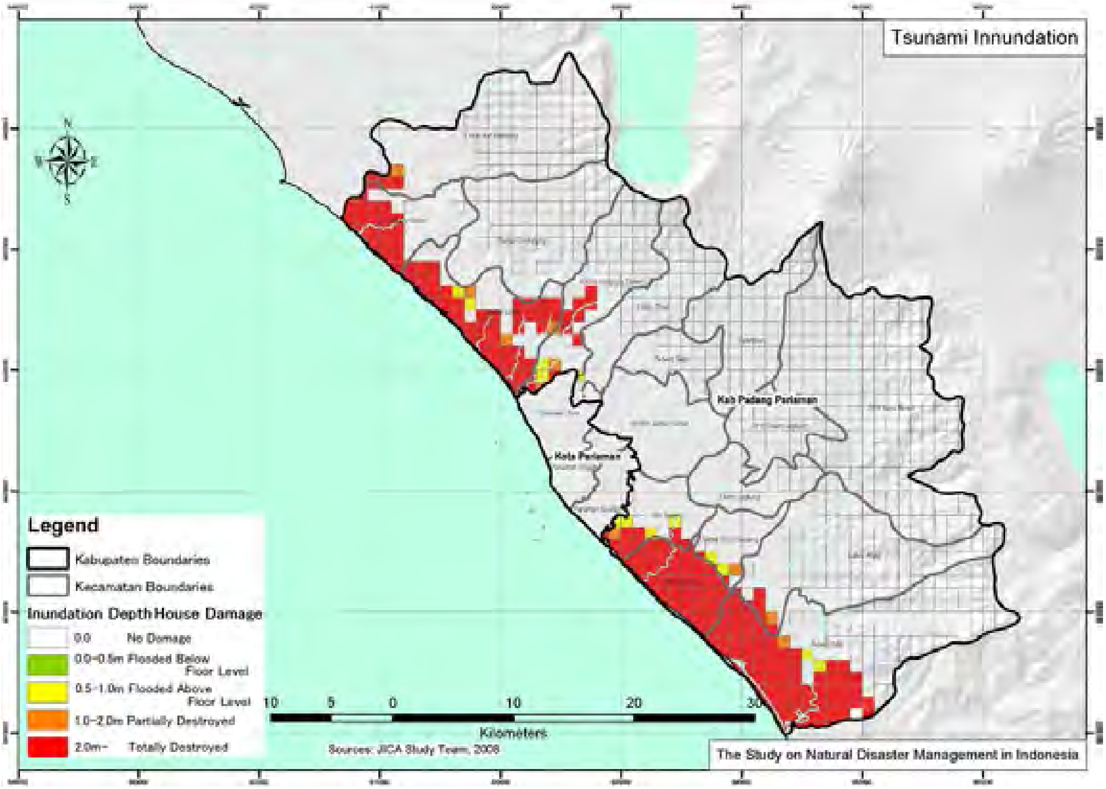


Figure 33 Inundation Area and Depth Estimated Based on Ground Elevation

d) Tsunami Hazard Map in Kabupaten Padang Pariaman

When the above-mentioned three indices are compared, the result on the dangerous side is given in the order of the inundation area based on ground elevation and the inundation area estimated by level filling method. Essentially, it is better to adopt the prediction method with the highest accuracy. In this study, the inundation area based on ground elevation, which gives the result on the most dangerous side and is comparatively easy to formulate, shall be adopted because all prediction methods have a problem with accuracy which depends on available data and its accuracy. An inundation map with higher accuracy can be formulated after the various data are maintained and available.

The hazard map for tsunami disaster was created based on Expected Inundation Depth. As indicated in Figure 34, the values of tsunami hazard were divided into 4 classes as shown below.

i)	2.0m<	(Totally destroyed)	Score 4	(Highest hazard)
ii)	1.0m<H≤2.0m	(Partially destroyed)	Score 3	(High hazard)

iii) 0.5m<H≤1.0m (Flooded above floor level) Score 2 (Moderate hazard)

iv) 0.0m<H≤0.5m (Flooded below floor level) Score 1 (Low hazard)

v) H=0.0m (No damage) Score 0 (No damage)

Figure 34 indicates that the tsunami hazard is concentrated on the 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 extends 5-7km from the coast to inland. Accordingly, the tsunami hazard area has extended deeply to inland.

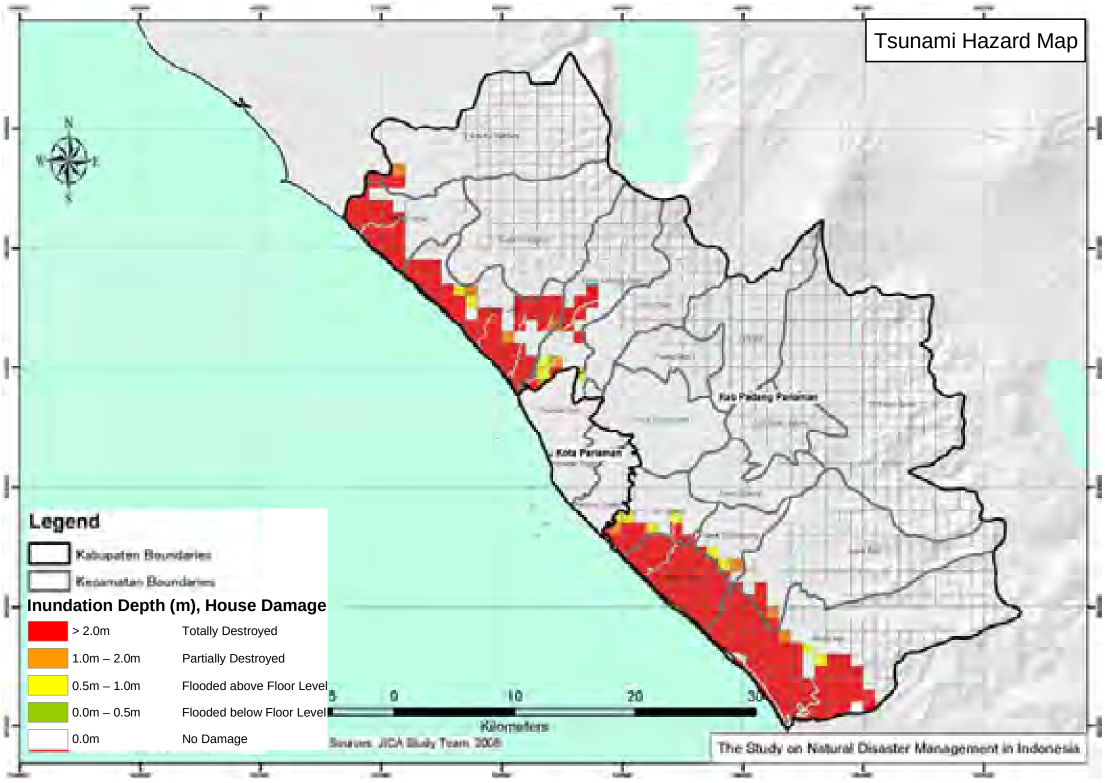


Figure 34 Tsunami Hazard Map

E. Maps for Vulnerability Indices

a) Population Density

To assess vulnerability of Kabupaten Padang Pariaman in terms of population density, a population density grade map at 1,000 m grid intervals was created based on the population density map (Figure 36). A scoring system to assess vulnerability in terms of population density was then applied based on the following classification.

i)	Score 5	: > 50	(pop./ha)	<Highest Population Density>
ii)	Score 4	: 25 – 50	(pop./ha)	<Higher Population Density>
iii)	Score 3	: 10 – 25	(pop./ha)	<Moderate Population Density>
iv)	Score 2	: 5 – 10	(pop./ha)	<Lower Population Density>
v)	Score 1	: <= 5	(pop./ha)	<Lowest Population Density>
vi)	Score 0	: 0	(pop./ha)	<No Population>

The figure below shows the vulnerability scoring for population density used by the study team.

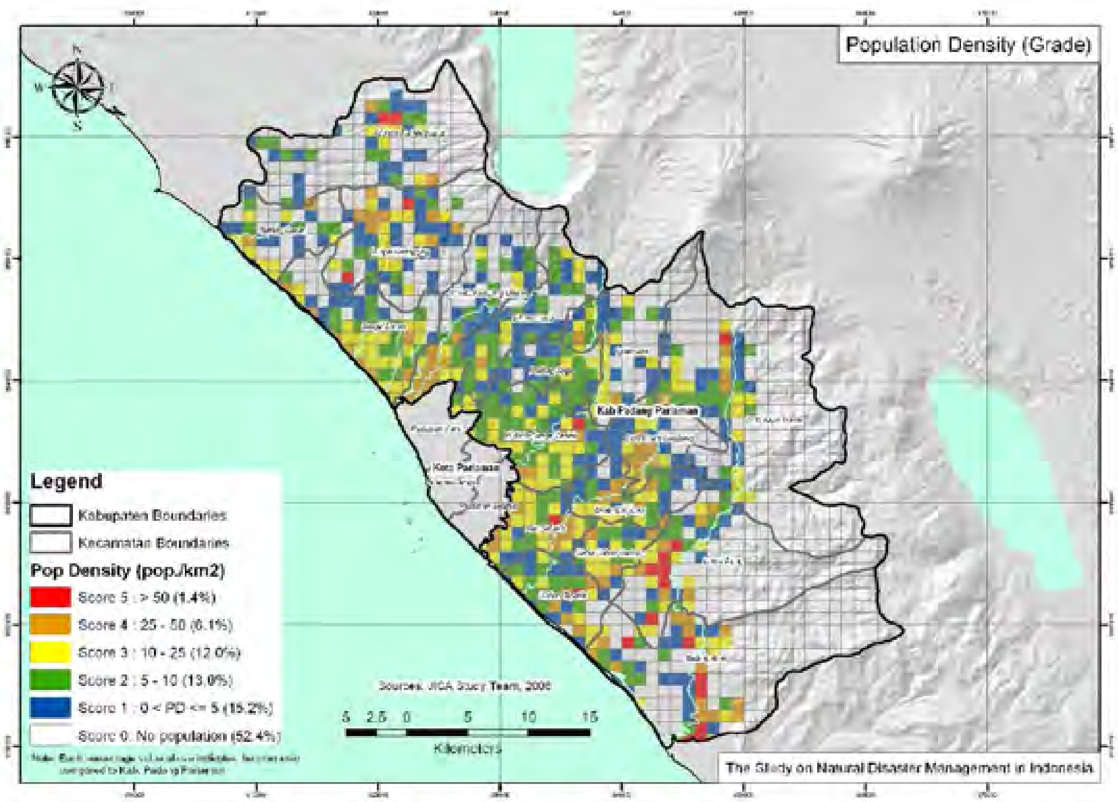


Figure 35: Population Density Grade in Kabupaten Padang Pariaman

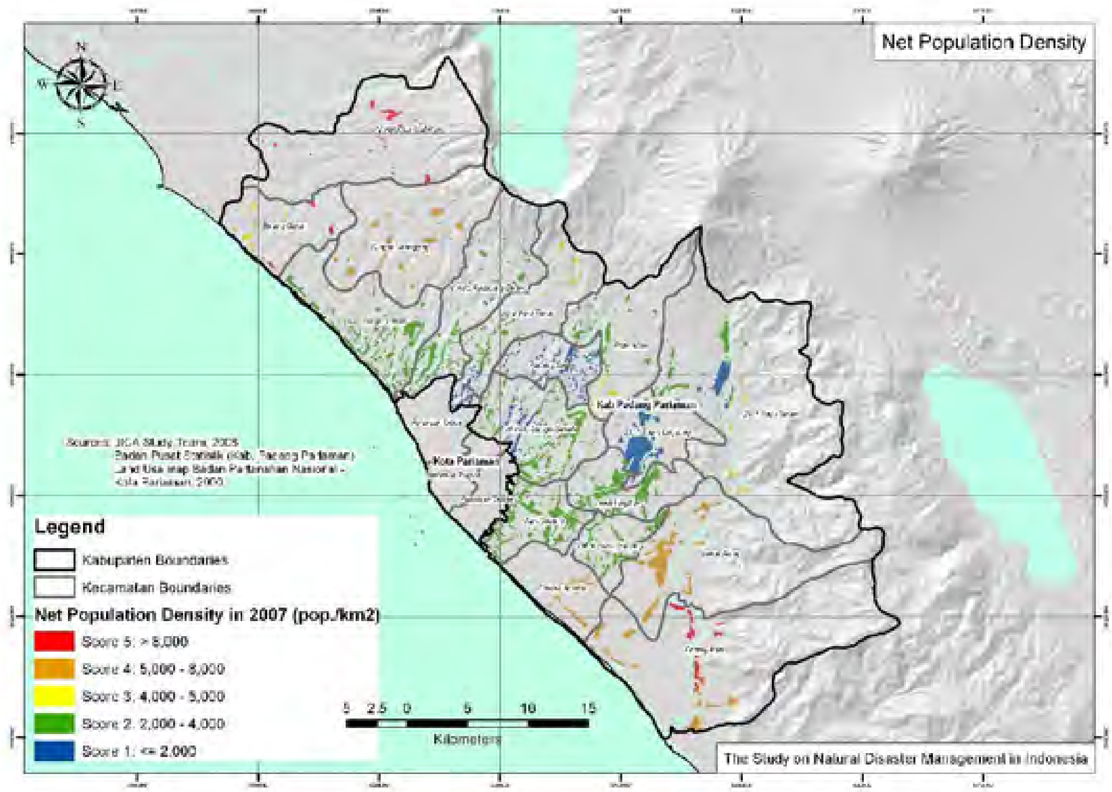


Figure 36 Population Density in Kabupaten Padang Pariaman

b) Built-up Area

To assess vulnerability of Kabupaten Padang Pariaman in terms of built-up area, a built up area grade map at 1,000 m grid intervals was created based on the built-up area map (Figure 38). A scoring system to assess vulnerability in terms of built up area ratio was then applied based on the following classification.

i)	Score 5	: > 50	(percent)	<Highest Ratio of Built-up Area>
ii)	Score 4	: 30 – 50	(percent)	<Higher Ratio of Built-up Area>
iii)	Score 3	: 20 – 30	(percent)	<Moderate Ratio of Built-up Area>
iv)	Score 2	: 5 – 20	(percent)	<Lower Ratio of Built-up Area>
v)	Score 1	: <= 5	(percent)	<Lowest Ratio of Built-up Area>
vi)	Score 0	: 0	(percent)	<No Building>

The figure below shows the vulnerability scoring for built-up area ratio used by the study team.

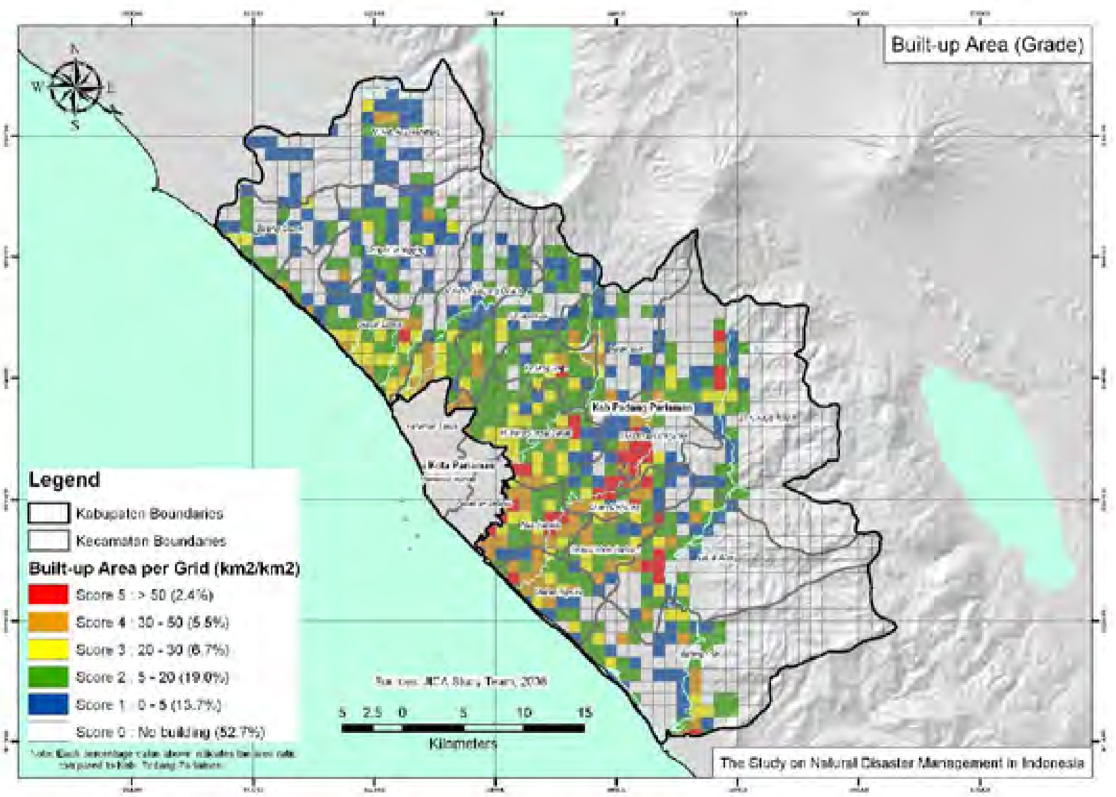


Figure 37 Built up Area Grade in Kabupaten Padang Pariaman

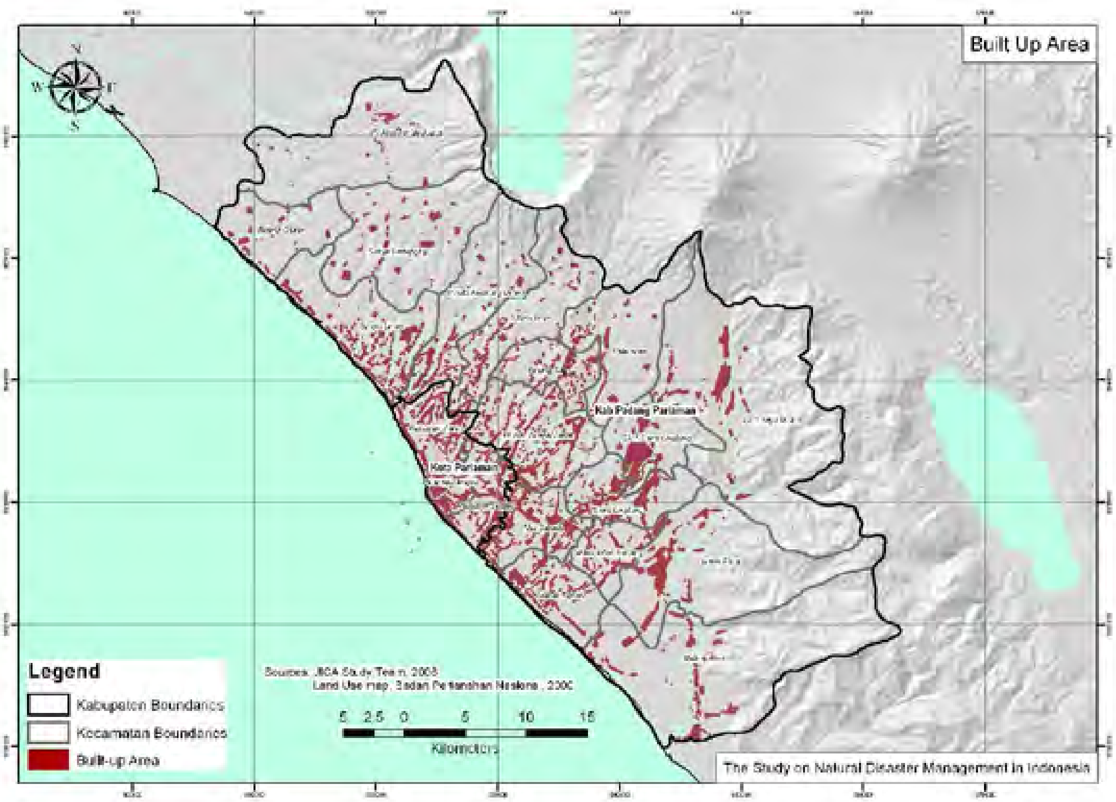


Figure 38 Built-Up Areas in Kabupaten Padang Pariaman

c) Road, Railway in Steep Slope Area

To assess vulnerability of Kabupaten Padang Pariaman in terms of the presence of road or railways in steep areas, a road/railway in steep area map at 1,000 m grid intervals was created based on the digital elevation grade map (Figure 14) as well as road and railway layers . Each grid is flagged if it satisfies the conditions that either a road or railway exists in the grid and that the grid has an average slope of greater than 30 degrees. A scoring system to assess vulnerability in terms of the presence of road or railway in steep areas was then applied. The figure below shows the vulnerability scoring for the presence of road or railway in steep areas used by the study team especially as one of vulnerability index for sediment disaster.

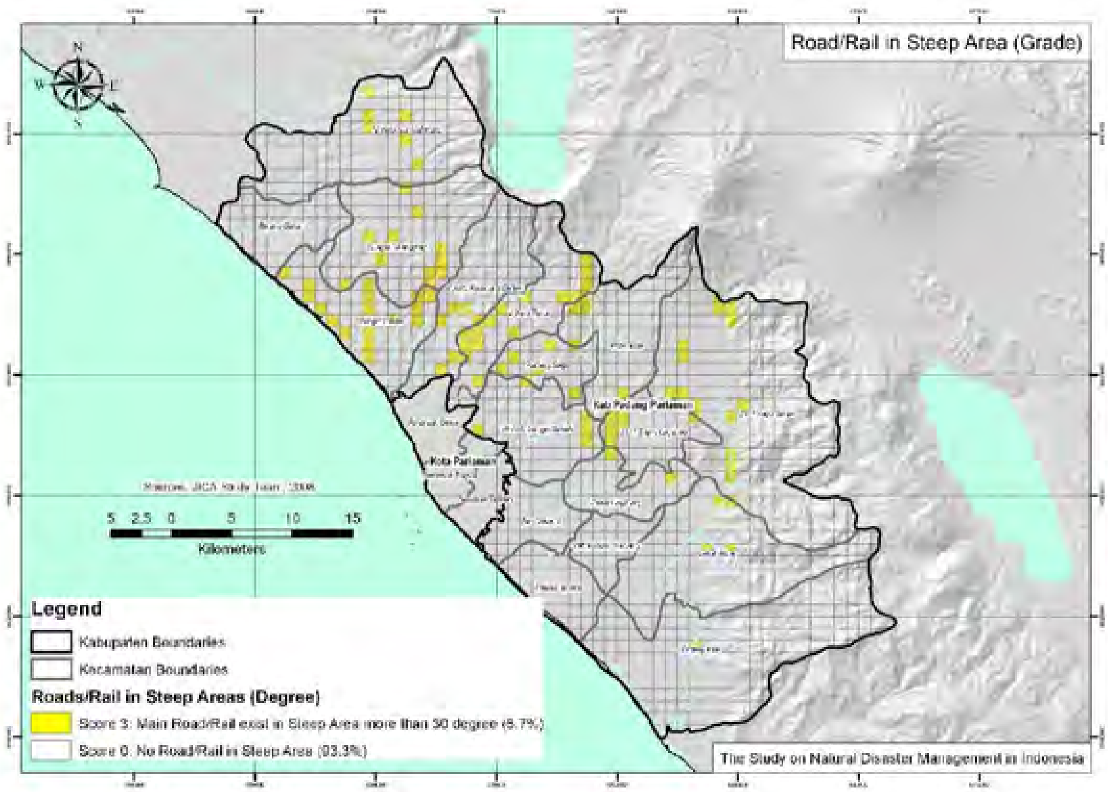


Figure 39 Grade for Road, Railway in Steep Slope Area in Kabupaten Padang Pariaman

d) Rice Field & Plantation

To assess vulnerability of Kabupaten Padang Pariaman in terms of plantation and rice field area grade, a plantation and rice field area grid map at 1,000 m intervals was created based on the land cover map (Figure 41). A scoring system to assess vulnerability in terms of plantation and rice field area cover types was then applied based on the following classification.

- i) Score 5 : > 80 (percent) <Highest Ratio of Rice and Plantation>
- ii) Score 4 : 50 – 80 (percent) <Higher Ratio of Rice and Plantation>
- iii) Score 3 : 30 – 50 (percent) <Moderate Ratio of Rice and Plantation>
- iv) Score 2 : 10 – 30 (percent) <Lower Ratio of Rice and Plantation>
- v) Score 1 : <= 10 (percent) <Lowest Ratio of Rice and Plantation>
- vi) Score 0 : 0 (percent) <No Rice and Plantation >

The figure below shows the vulnerability scoring for plantation and rice field area cover type used by the study team especially as one of vulnerability index for flood disaster. As shown in the figure, most of highest ratio of plantation and rice-field are concentrated in flat lowland such as Kec. Batang Anai, Kec. Lubuk Alung, Kec. Ulakan Tapakis and Kec. Nansabris.

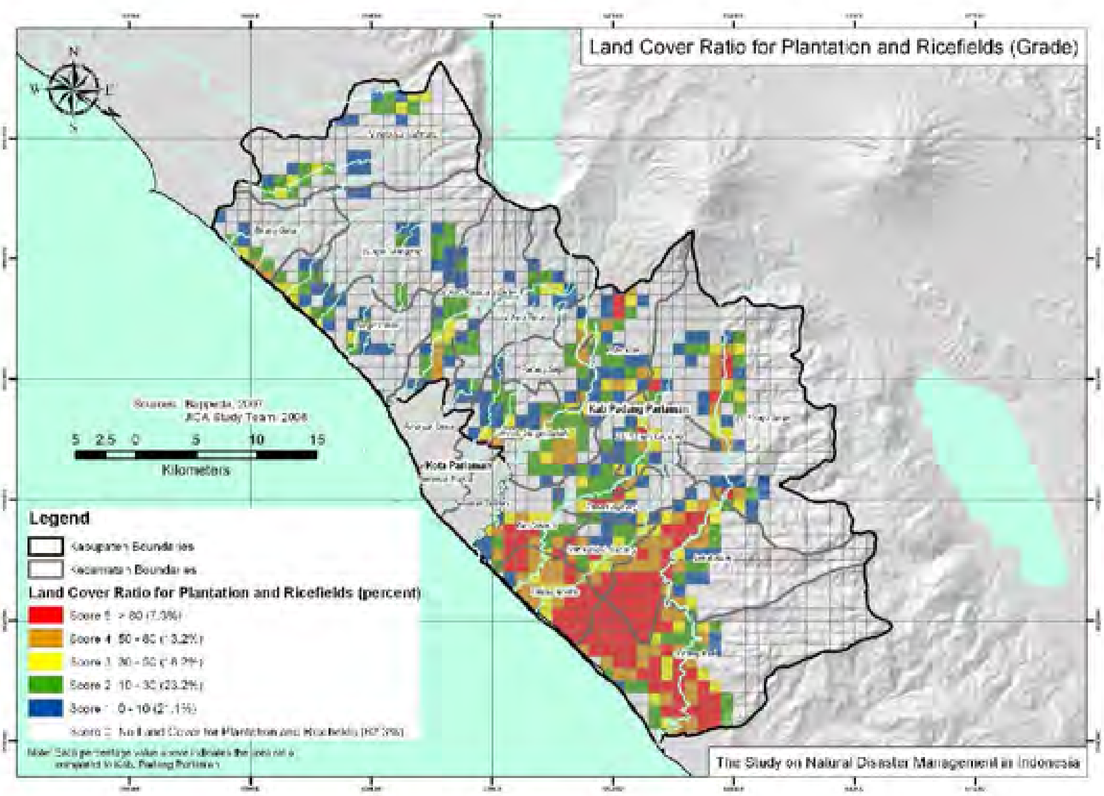


Figure 40 Grade for Rice Field & Plantation in Kabupaten Padang Pariaman

Figure 41: Land Cover in Kabupaten Padang Pariaman

e) Distance from coastline

"Distance from coastline" was selected as one of the indices of tsunami vulnerability. The grade and the corresponding scores are as follows:

i)	0km=<L<1.0km	(Serious Damage)	・・・Score 5
ii)	1.0km<L<3.0km	(Partially Damage)	・・・Score 3
iii)	3.0km=<L	(No Damage)	・・・Score 0

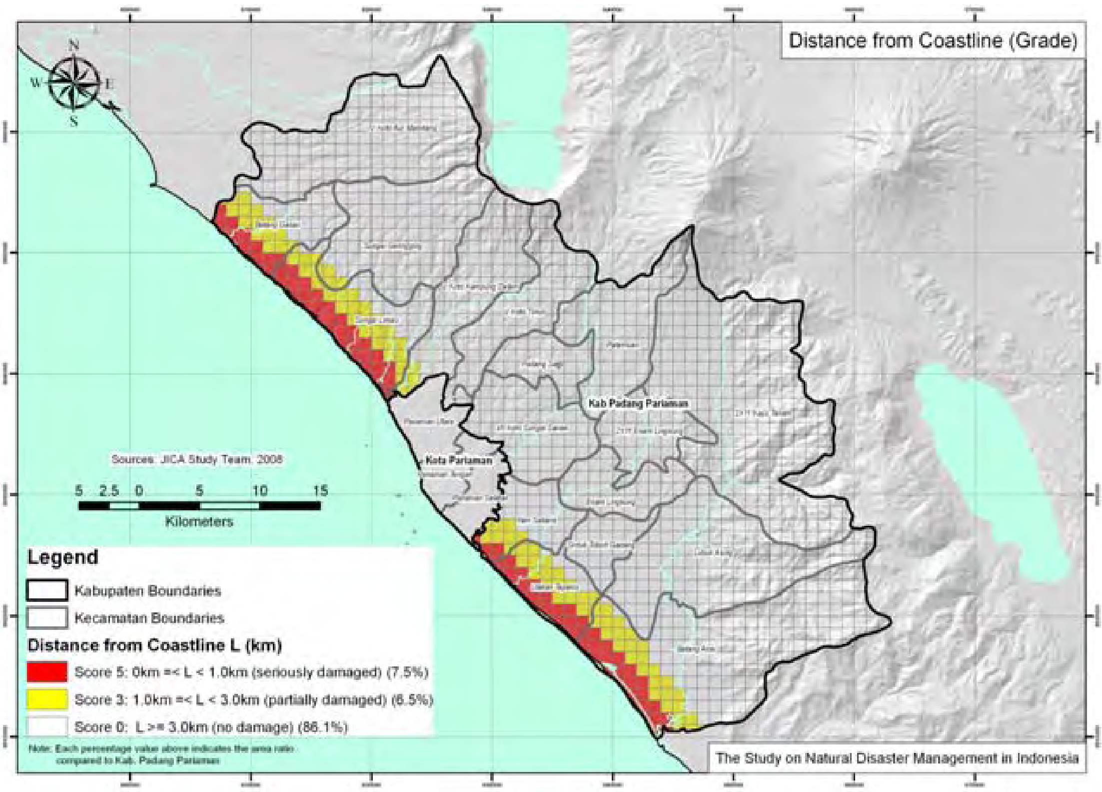


Figure 42 Distance from the Coastline

7 CREATION OF RISK MAP

After the preparation of the selected indices of "Hazard" and "Vulnerability", the risk map can be created as the result of the formula of "Risk = Hazard x Vulnerability".

After the preparation of the selected indices of "Hazard" and "Vulnerability", the risk map can be created as the result of the formula of "Risk = Hazard x Vulnerability". The most appropriate indices for hazard and vulnerability can be selected amongst the candidate indices after the trial derivations of risk map.

Hereinafter, the procedures of risk maps which have been prepared for Kabupaten Padang Pariaman are introduced briefly as example case.

A. Risk Map for Flood Disaster

a) Basis of Risk Map Creation for Flood Disaster

The vulnerability indices are shown in Table 8.

Table 8 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.

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

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

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.

b) Flood Risk Map in Kabupaten Padang Pariaman

The risk map for flood disaster in Kabupaten Padang Pariaman is shown in Figure 43. Basically, higher risk area may be regarded as the area where population and property are concentrated, being 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 coastal line 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.

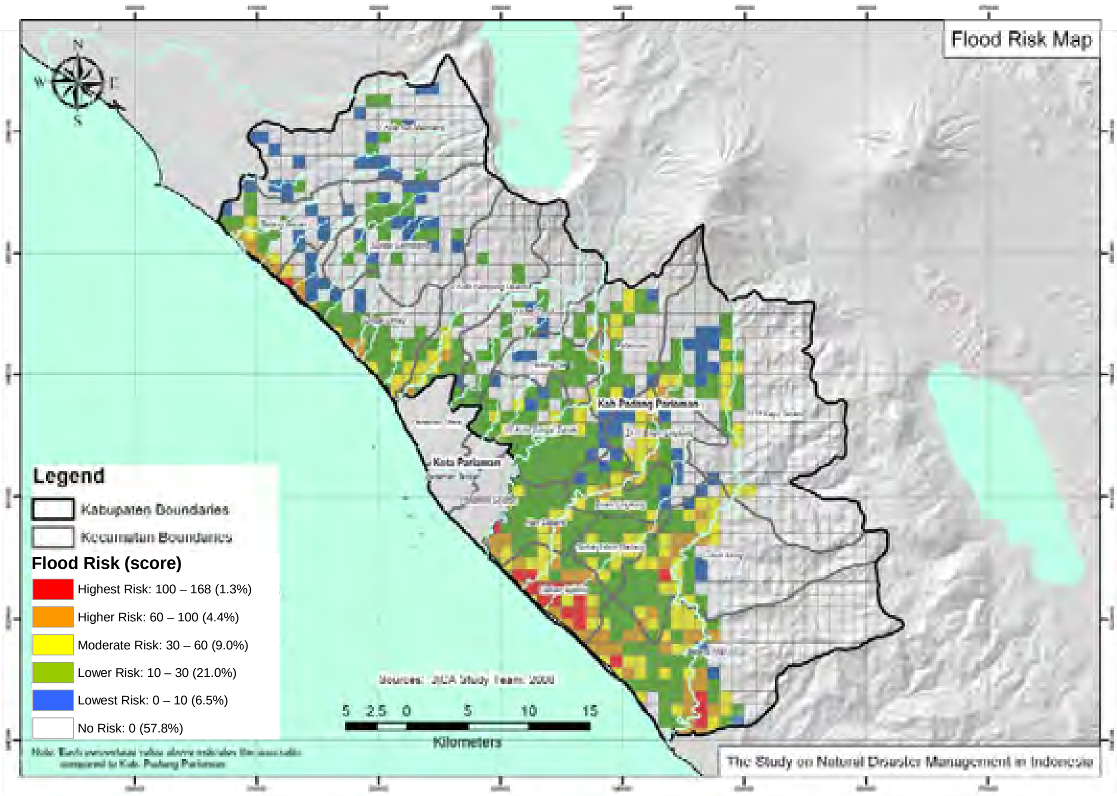


Figure 43 Flood Risk Map for Kabupaten Padang Pariaman

B. Risk Map for Sediment Disaster

a) Basis of Risk Map Creation for Sediment Disaster

The vulnerability indices are shown in Table 9.

Table 9 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 x Vulnerability

$$Risk = (H_{P4} + H_{P5} + H_{P6}) \times (V_{P1} + V_{P2} + V_{P4})$$

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 44 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 a number of sediment disasters along roads by steep slopes in mountainous areas or coastal terraces in the past. Even though higher sediment hazards are indicated in the eastern region of Kabupaten Padang Pariaman, risk indications in the region are not high since the vulnerability indices are not so high. 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 most of Kabupaten Padang Pariaman is in high sediment hazard area, detailed surveys and investigations are required prior to the implementation of land use plans.

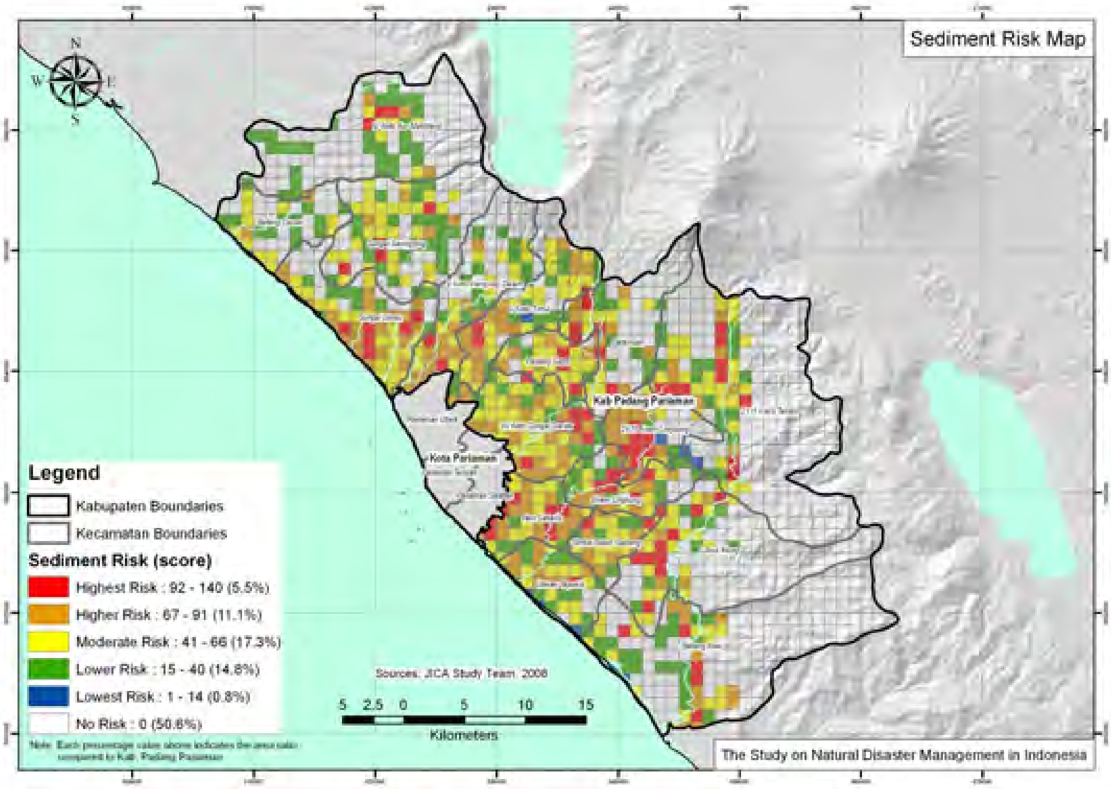


Figure 44 Sediment Risk Map for Kabupaten Padang Pariaman

C. Risk Map for Earthquake

a) Basis of Risk Map Creation for Earthquake

Earthquake risk is an abstract concept by itself. So some definition or physical understanding must be supplied. Earthquake disaster risk is the possibility of destruction that can be analyzed as a synergistic result of earthquake hazard and vulnerability of a facility. Every aspect of the magnitude in earthquake disaster, including human loss and economical loss, can be evaluated based on structural destruction. In an actual disaster situation people are not killed by quake of ground but they are killed by collapsing of buildings. As shown in Figure 45 the majority cause of death in 1995 Great Hanshin Earthquake originated almost always in the collapse of the building. Therefore it can be said that it is indispensable to know how many buildings shall collapse when we discuss the risk of earthquakes.

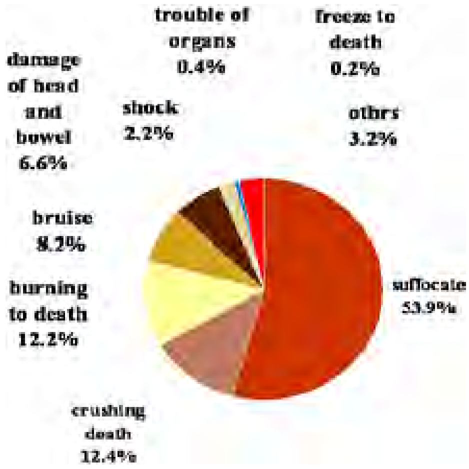


Figure 45 Ratio of the Cause of Death at 1995 Great Hanshin Earthquake

Therefore Earthquake risk is defined as the damage ratio P under the condition of assumed ground motion and characteristics of the buildings. The damage ratio P is defined by the equation.

$$P = \frac{N_D}{N_T}$$

Where,

N_D : Number of damaged building

N_T : Total number of existing building

In this context damaged buildings means the buildings that suffer equal or more "large damage" defined by Architectural Institute of Japan (AIJ). The damage grade "large damage" is strictly defined from the viewpoint of structure engineering. Generally, dead and injured are generated in the buildings that suffer equal or more "large damage". That is why this grade was chosen for the target of this evaluation. This grade is also similar to "Grade 4 Very Heavy Damage" of European Macroseismic Scale (EMS).

The damage ratio P is assessed by utilizing the fragility function. The outline of the fragility function analysis utilized in this study is shown in Figure 46.

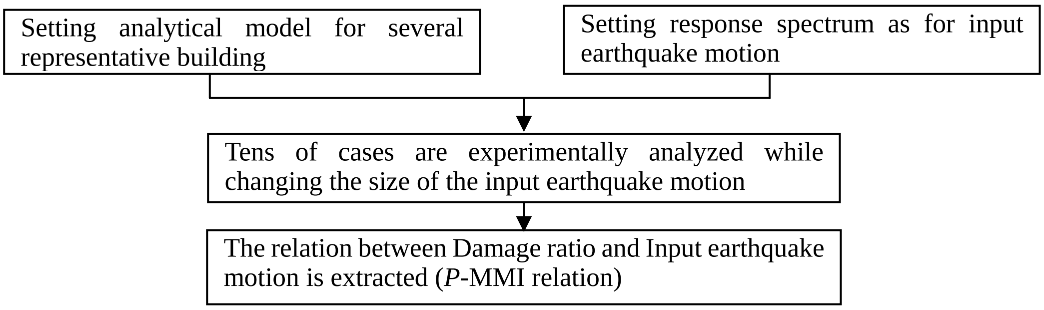


Figure 46 Outline of Fragility Function Analysis

The fragility function mainly depends on the characteristics of building structure. Therefore the buildings in the study area are divided into several building types and the typical building of each building type is modeled. Outline of building model is shown in Figure 47.

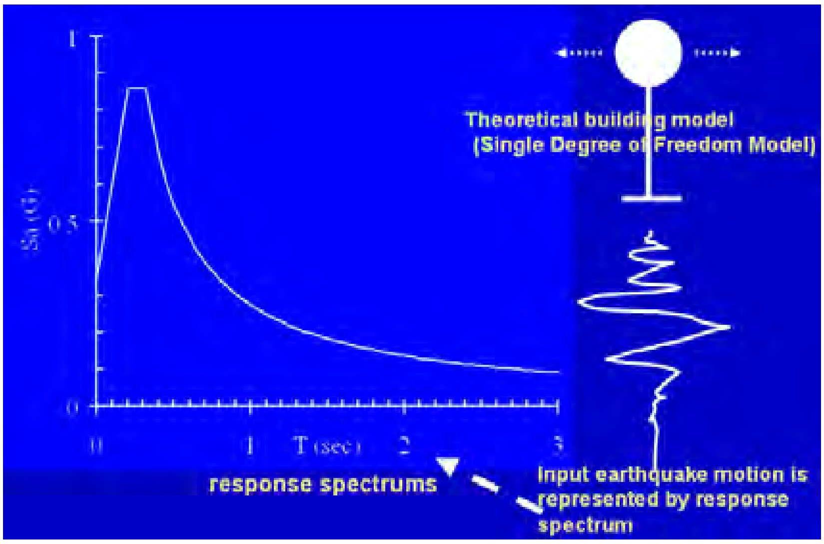


Figure 47 Outline of Building Model

Then a simplified dynamic analysis is carried out applying increasing earthquake input motion step by step. Then the relationship between MMI and the damage ratio *P* is obtained as a fragility function. The procedure to generate the relationship between MMI and the damage ratio *P* is common to the procedure done by committee of Japanese government and US Project “HAZUS”.

A highly probable result can not be obtained when the sensitivity of the fragility function does not fit real earthquake resistance of the buildings in a corresponding study area. In this study some steps of calibration were carried out applying consideration through the research report of past earthquake disasters that occurred near the study area. The example of Yogyakarta city (i.e, 27 May 2006 Yogya Earthquake M_W6.5) was a effective material to apply because a Japanese reconnaissance team reported the intensity of surface ground motion investigated through interview intended for the residents and some observation on damage state of the building in disaster area (Shiro Takada et. al "Strong Ground Motion and Lifeline Damage during the Java Jogjakarta Earthquake").

The obtained relationship between MMI and the damage ratio P is shown in Figure 48. The fragility function is generated for each building type.

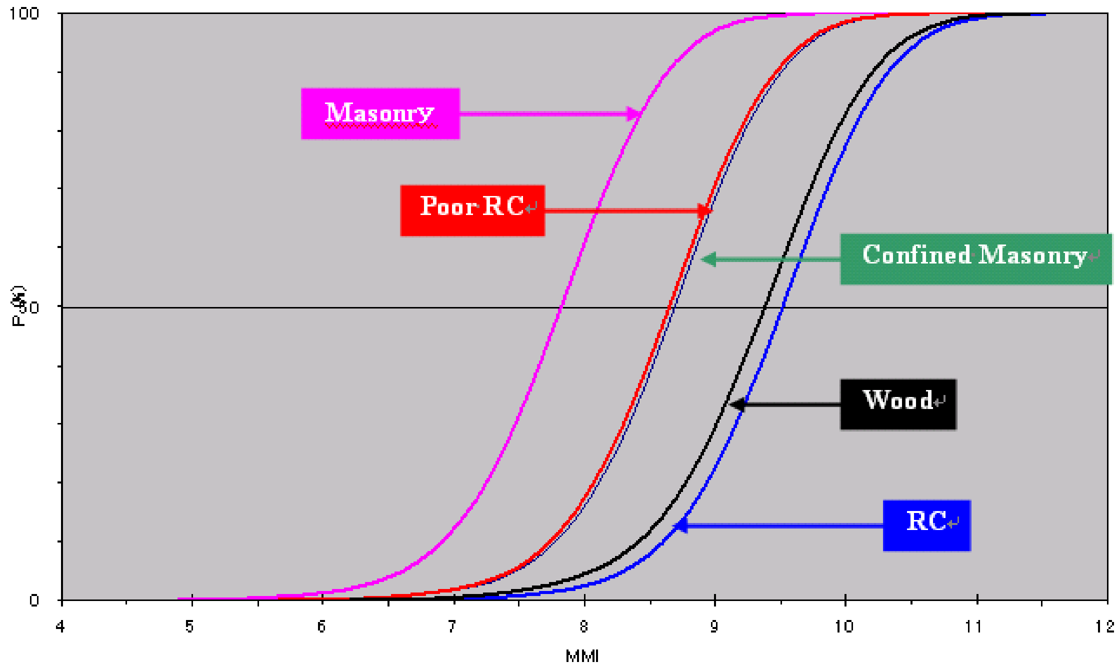


Figure 48 Fragility Function (Relationship between MMI and the damage ratio P)

On the other hand the damage example observed in Sumatra Island also needs to be referred. Therefore some report about 2004 Andaman earthquake and 2007 Solok earthquake were referred and it was confirmed that these observations do not contradict the fragility function.

In this report the hazard map shows the expected surface ground motion intensity of each point by MMI. So the value of the damage ratio *P* can be obtained by applying the fragility function and referring the value of MMI. By using a database and that indicates the number of each building type, the expected number of damaged buildings can be calculated by multiplying existing building number and the damage ratio *P*.

If above estimation is carried out based on enough grounds

- It can be known how large project of building strengthening is needed for disaster mitigation view point
- Expected number of dead and injured at earthquake can be estimated and

- Scale of preparedness required for emergency aid can be estimated

However in this study, gaps in the database had to be filled by referring to some survey results and rough considerations because the database which was obtained now did not offer detailed information. The responsible Agency in Kabupaten Padang Pariaman has to implement the building census from the structural viewpoint and improve the database in the future.

2) Earthquake Risk Map in Kabupaten Padang Pariaman

The intensity of surface ground motion differs according to the location. The vulnerability of the building also differs according to the building type. For instance the reinforced concrete building, which was designed and constructed through modern design concepts, is sustainable with 10% or less of damage ratio even if the intensity of surface ground motion is equal to MMI 8 or more, but the unreinforced masonry building may suffer damage with near to 90% of damage ratio. There is some difficulty to wrap up the risk map to only one figure because of above situation.

Figure 49 shows the expected number of damaged buildings that are located in each grid square of 1km×1km. The tendency of the distribution of damaged buildings that depends on vulnerability of existing buildings is shown. In a word there is high risk at the location where vulnerable buildings exist.

Figure 50 shows the value of the expected number of damaged buildings divided by the total number of existing buildings that is located in each grid of 1km×1km. This indicates the average damage ratio for each grid and thus it shows the tendency more clearly than previous Figure 49.

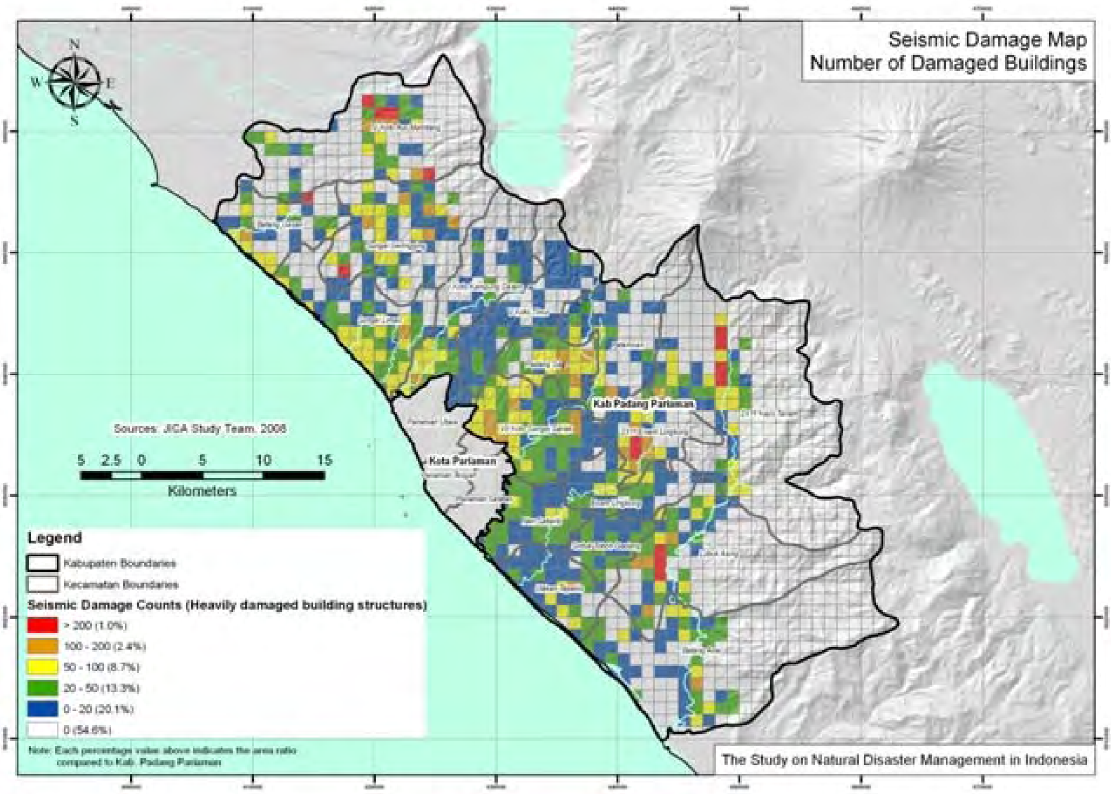


Figure 49 Building Damage Per Grid

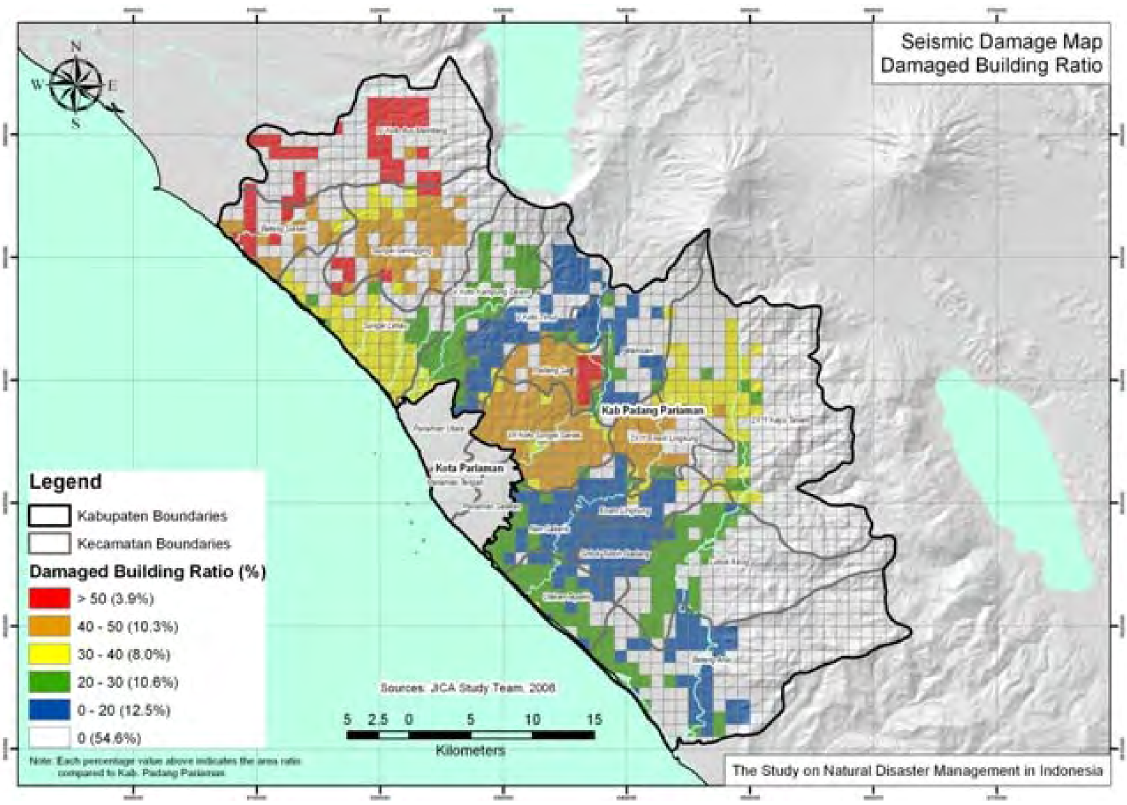


Figure 50 Building Damage Ratio Per Grid

D. Risk Map for Tsunami Diaster

a) Basis of Risk Map Creation for Tsunami Disaster

The vulnerability indices are shown in Table 10.

Table 10 Vulnerability Indices Used for Tsunami Disaster

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

$$Risk = H_{P3} \times V_{P3} \times (V_{P1} + V_{P2})$$

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 51 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.

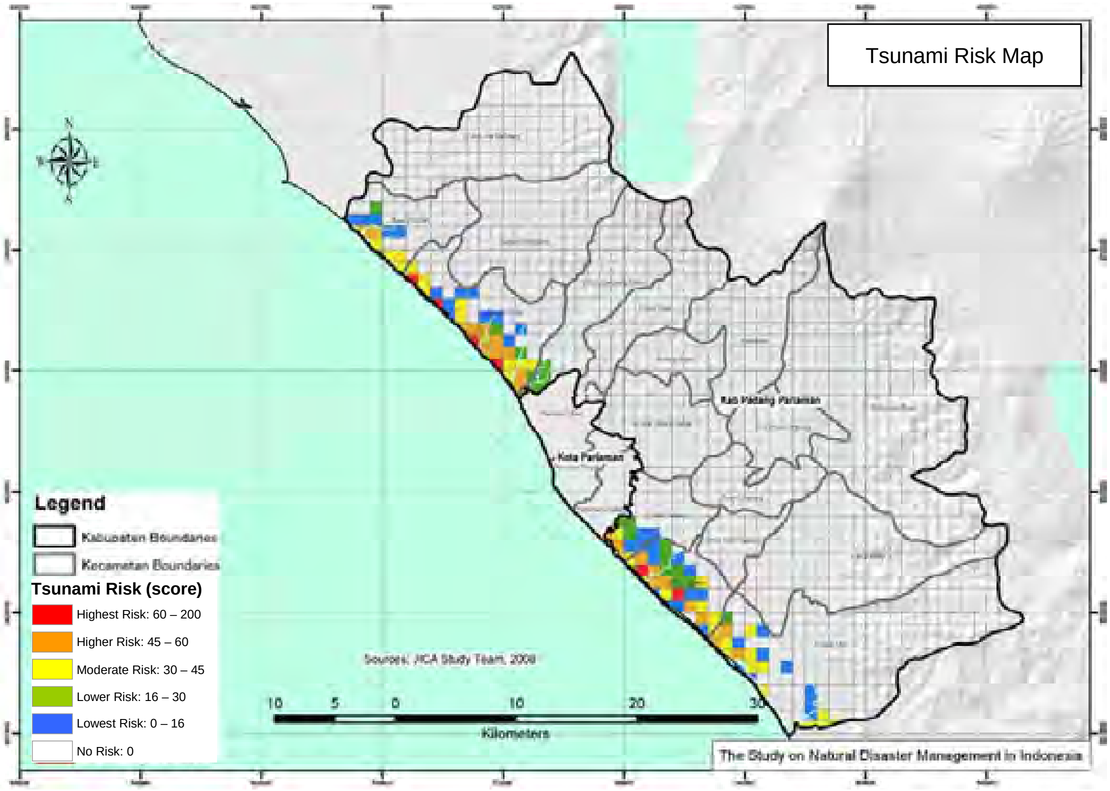


Figure 51　　Tsunami Risk Map for Kabupaten Padang Pariaman