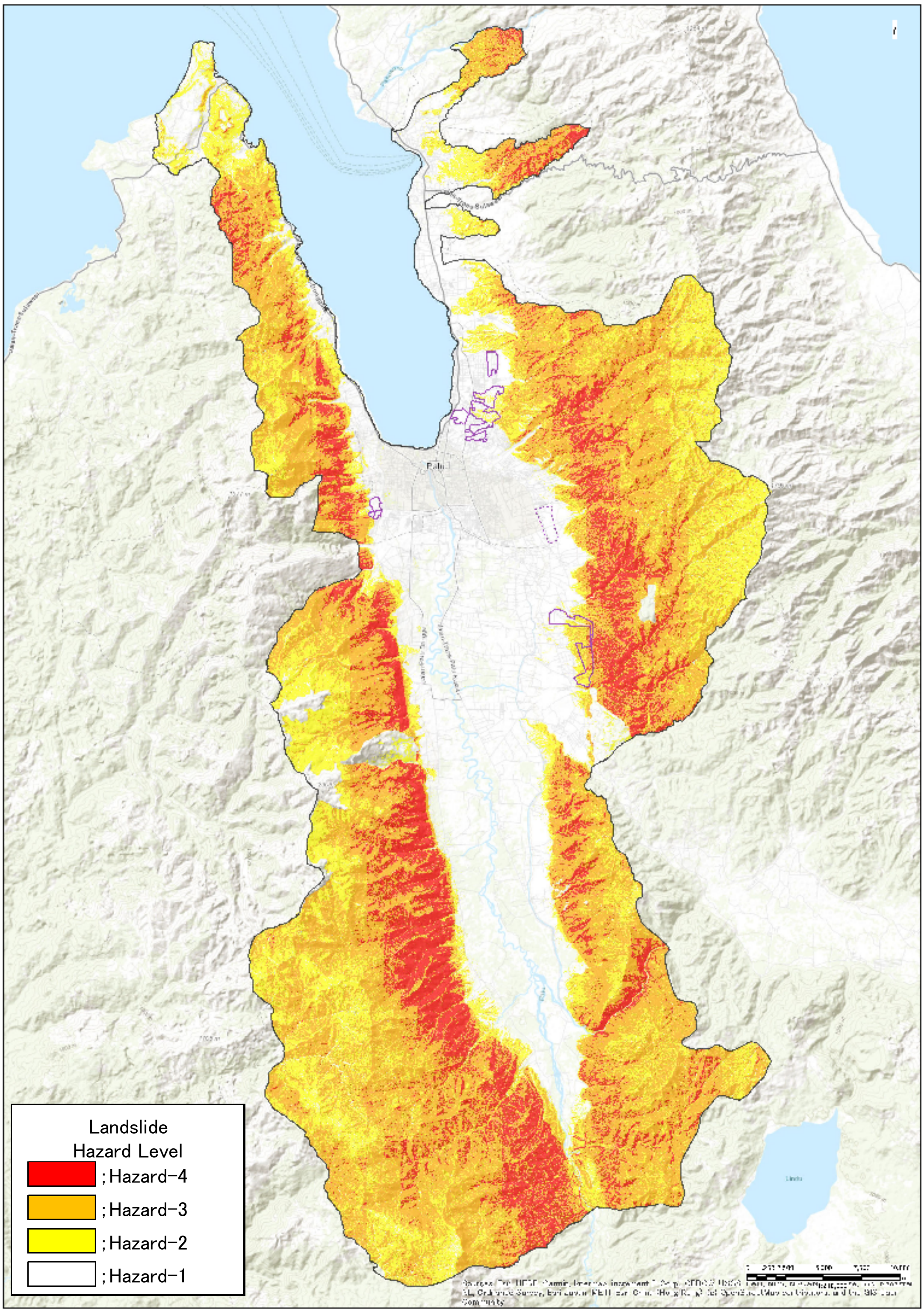
b) Create Hazard Map for BG Landslide

The hazard map for landslide was created with weighting 6 parameters. The hazard map for landslide created by BG is shown in figure below.

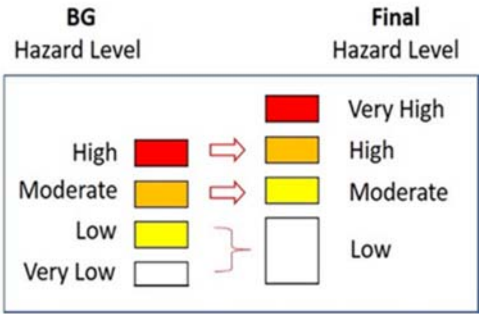


Source: JICA Expert and JICA Study Team

Figure 6-89 Hazard Map for Landslide by BG

3） Finalization of Hazard Map for Steep Slope Collapse and Landslide

The hazard map for Steep Slope Collapse and landslide shall be finalized by combining the hazard map for Steep Slope Collapse created by JICA Study Team and the hazard map for Landslide created by BG. In addition, the hazard assessment of BG basically consists of three categories of “High”, “moderate” and “low”. Therefore, the final assessment criteria as shown below are set with reference to JICA's assessment criteria (four levels/reference Figure 6-90). This concept was agreed on by JICA Study Team and BG.



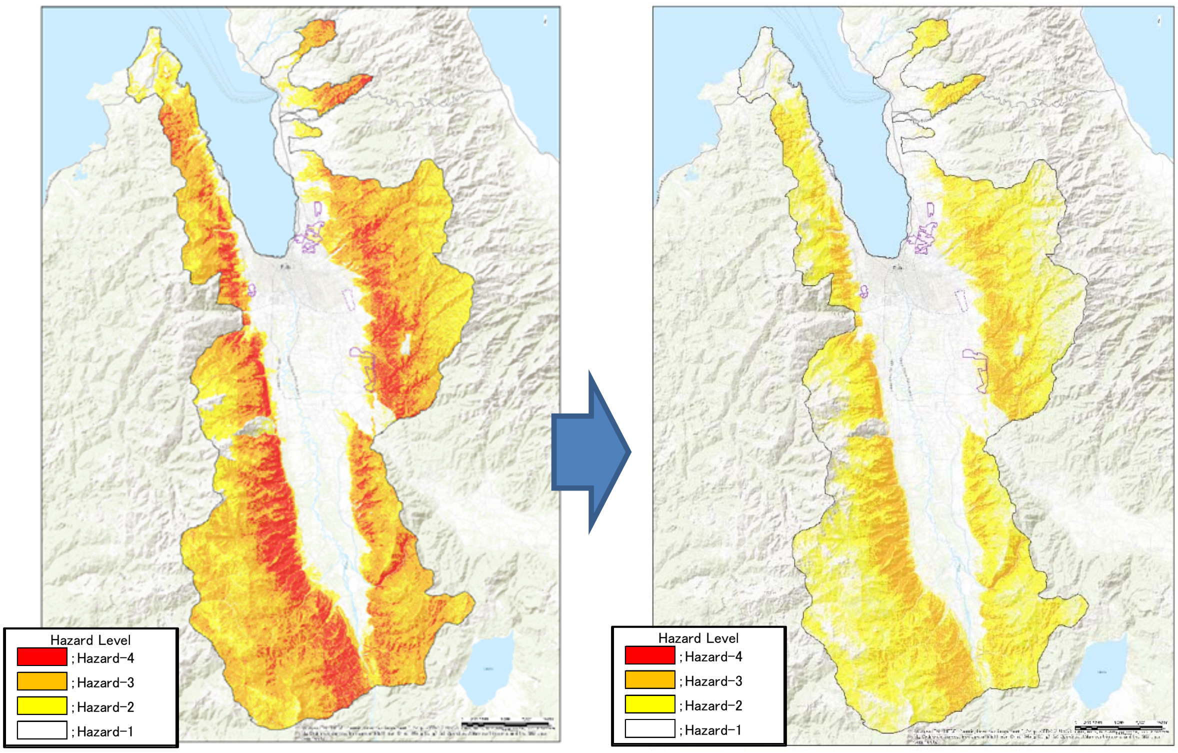
Source: JICA Expert and JICA Study Team

Figure 6-90 Review of Hazard level of BG

The method for the finalization of Hazard Map is shown below.

a) Review of Hazard Level

The hazard level of hazard map for Landslide created by BG has been lowered by one rank.



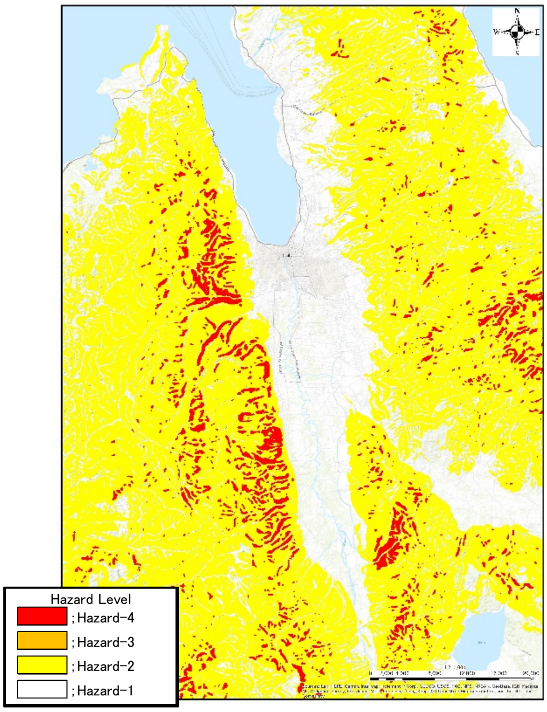
① BG’s Original Map for Landslide ② BG’s Map for Landslide after Review

Source: JICA Expert and JICA Study Team

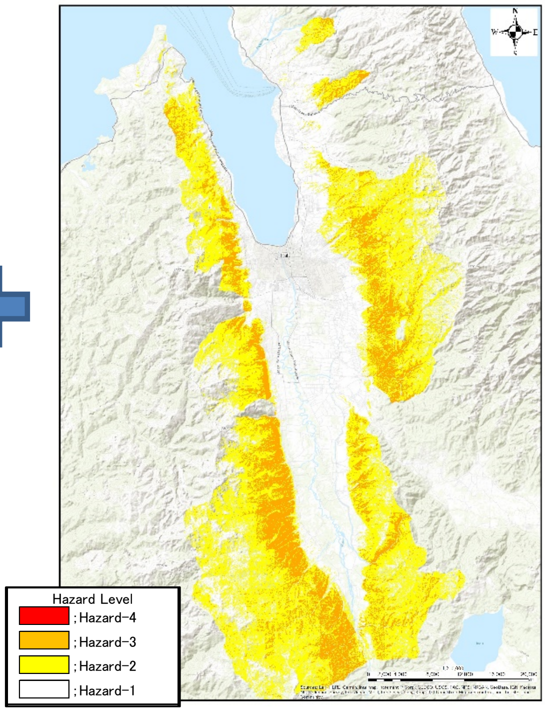
Figure 6-91 Review of Hazard level of BG

b) Combining of Hazard Map

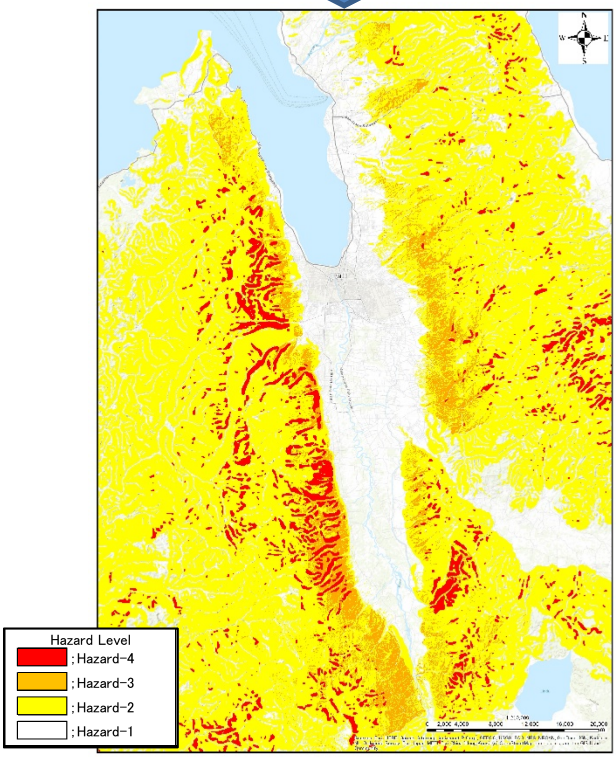
The hazard map for Steep Slope Collapse created JICA Study Team and the hazard map for landslide after reviewing hazard level are combined and finalized.



③ JICA: Original of Steep Slope Collapse



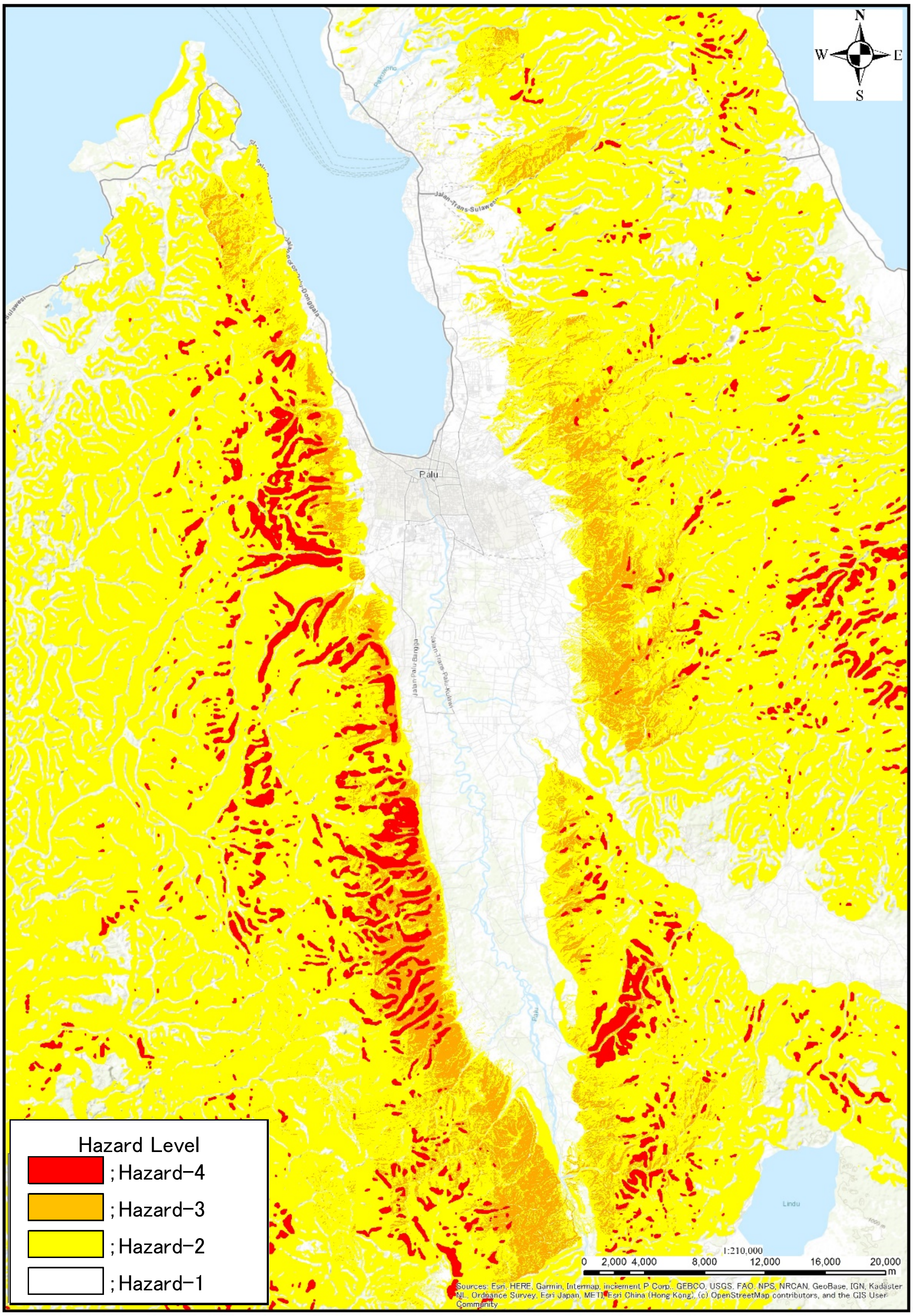
② BG's Map for Landslide after Review



③ JICA: Original of Steep Slope Collapse + ② BG's Map for Landslide after Review
(Combined Map)

Source: JICA Expert and JICA Study Team

The finalized hazard map for Steep Slope Collapse and landslide is shown in the figure below.



Source: JICA Expert and JICA Study Team

Figure 6-92 Hazard Map for Steep Slope Collapse and Landslide

4） Flash Flood

The flowchart for the creation of hazard map for Flash Flood is shown in the figure below.

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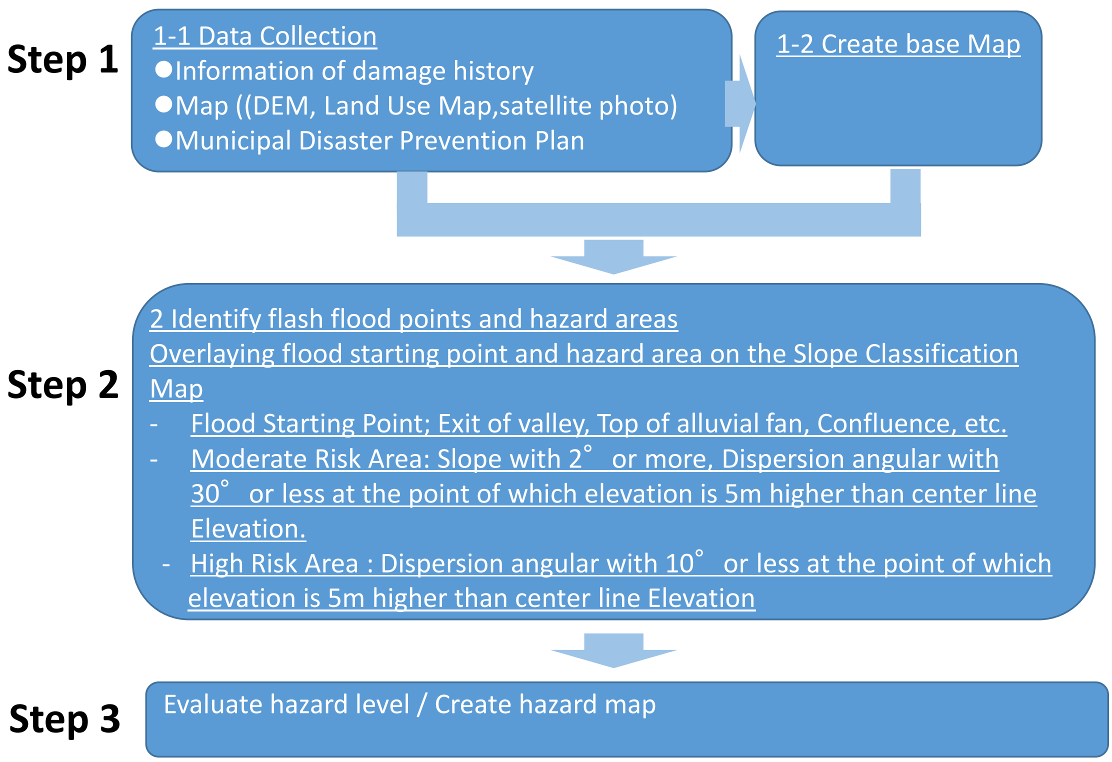


Source: JICA Expert and JICA Study Team

Figure 6-93 Flowchart for the Creation of Hazard Map for Flash Flood

The details of the creation method of the hazard map is shown below step by step.

BG does not have the standard for creating the hazard map for flash flood. Therefore, the hazard map for flash flood shall be created based on the Japanese technical standard.

➢ Data Collection and Create Base Map

The satellite image data (DEM) of 30m mesh shall be collected to understand geomorphology characteristics. First, the contour map and the slope map shall be made by DEM (same to Steep Slope Collapse).

➢ Identify Flash Flood Points and Areas

a) Hazard Criteria

In order to set up the Disaster Hazard Criteria, Japanese technical standard (Steep Slope Law, Landslide Prevention Law) was borrowed. Under the Japanese standard, the flash flood sediment deposit normally settles at the river section with between 2 degree and 15 degree slope. In order to evaluate the last disaster, there is a very limited data and information about river slope angle and others, so that where the flash flood sediment deposition starts is set as shown in the following explanation of (a) and where the settlement stops is set at the location with 2 degree slope. Sediment deposition spread zone is also set as 30 degree horizontal view from the flash flood movement center line in accordance with the Japanese standard. Among the 30 degree sediment deposition settlement, the area with in the 10 degree zone in horizontal view in both sides of the flash center line is set as highly dangerous zone (with more potential of sediment settlement could occur).

Table 6-24 Classification of Hazard Level for Flash Flood

Hazard Level	Sloop & Wide	Setting range
4	---	**Not set ; Because evacuation is possible** **The situation is different from the disaster caused by the earthquake. As it is possible to secure evacuation time because Flash flood occurs when rainfall continues.**
3	**Start Point～Slope≧2° & Dispersion Anglar≦10° &5m higher than center Line height**	The high risk areas where dispersion angular is 10°or less at the point of where elevation is 5 m higher than center line elevation
2	**Start Point～Slope≧2° & Dispersion Anglar≦30° &5m higher than center Line height**	The areas where slope with 2°or more and dispersion angular with 30°or less at the point of which elevation is 5 m higher than center line Elevation shall be extracted.
1	**Other areas**	**---**

Note: Flash flood has its straight running tendency. On the other hand, natural flow of debris is normally expected to spread in 30° angle, however Flash flood may easily flow within 10° angle zone near the flow center line. Based on this assumption, Hazard Level-3 and Hazard Level-2 are separately defined.

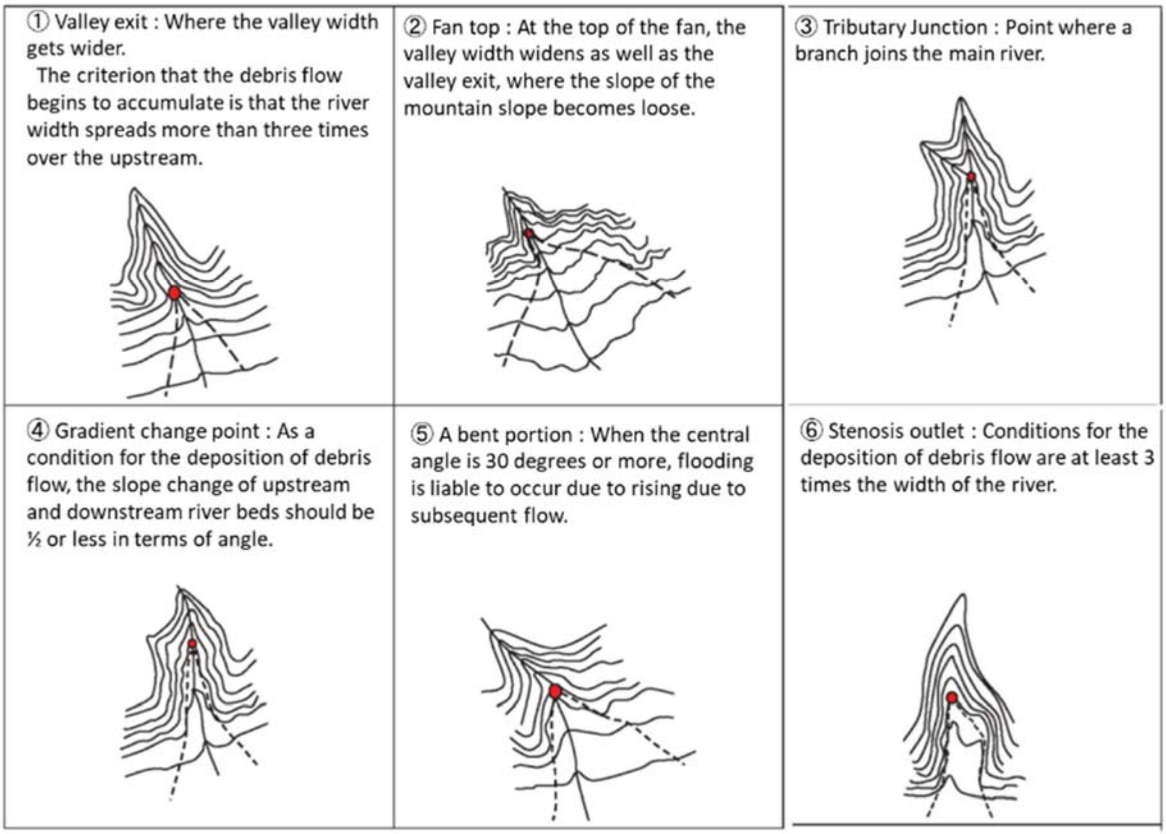
b) Flood Starting Point

The starting point of flood is set base on the contour map. Generally, the following points; valley exit, fan top, tributary junction, gradient change point, bent portion and stenosis outlet, are recognized as flood's starting point. General starting points for flood are shown in Figure 6-94.

Table 6-25 Terrain Features of Starting Points for Flash Flood

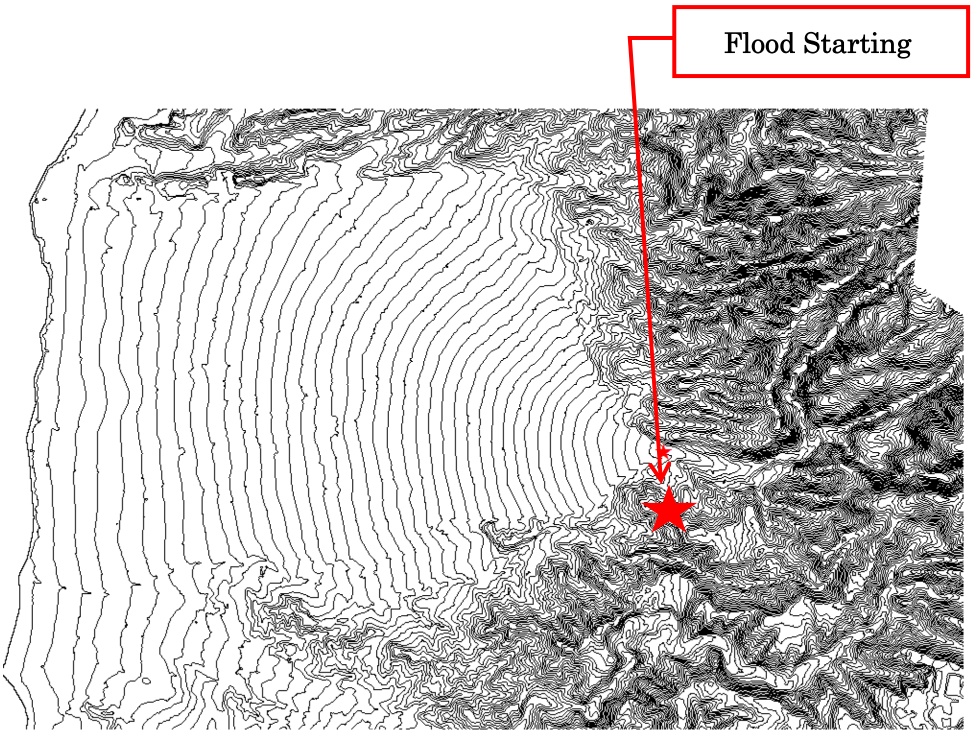
No	Flood Starting Point	Terrain features
1	Valley exit: The river	At the point where the river width spreads more than three times from upstream
2	Fan top	At the top of the fan, at the point where the valley widths spreads and the slope of the mountain floor becomes loose
3	Tributary junction	At the point where the branch river joins the main river
4	Gradient change point	At the point where slope change of upstream and downstream. Changing angle is 1/2 or less.
5	Bent portion	At the point where the ratio(r/b) of channel width(b) to curvature radius(r) is less than 1/10
6	Stenosis outlet	At the point where the river width spreads more than three times from upstream

Source: Basic Survey Manual for Prevention of Sediment Disasters (draft) (General): Iwate Prefecture, March 2015



Source: Basic Survey Manual for Prevention of Sediment Disasters (draft) (General): Iwate Prefecture, March 2015

Figure 6-94 General Flood Starting Points

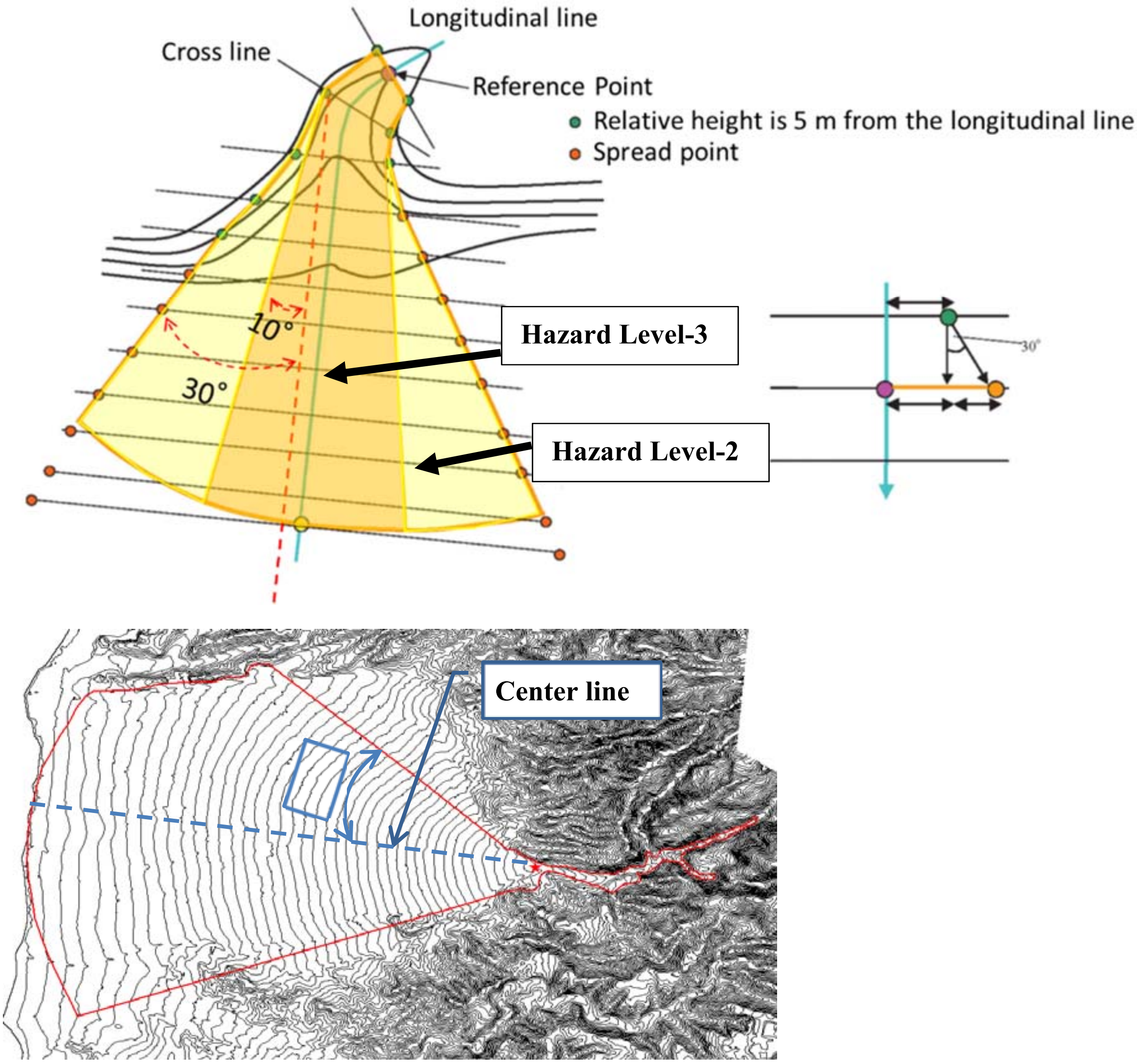


Source: JICA Expert and JICA Study Team

Figure 6-95 Setting the Flash Flood Starting Point c）Extraction of the hazard Area

At first, the reference point should be set along the longitudinal line, which could be the center line of a river or stream. The points where is higher than center line 5m along the cross line perpendicular to the longitudinal line from the reference point should be set. Where the distance between the points of 5m higher than center line and the longitudinal line becomes wider, spread points shall be set by 10° or 30° angle to the 5m height line in relation to the longitudinal line.

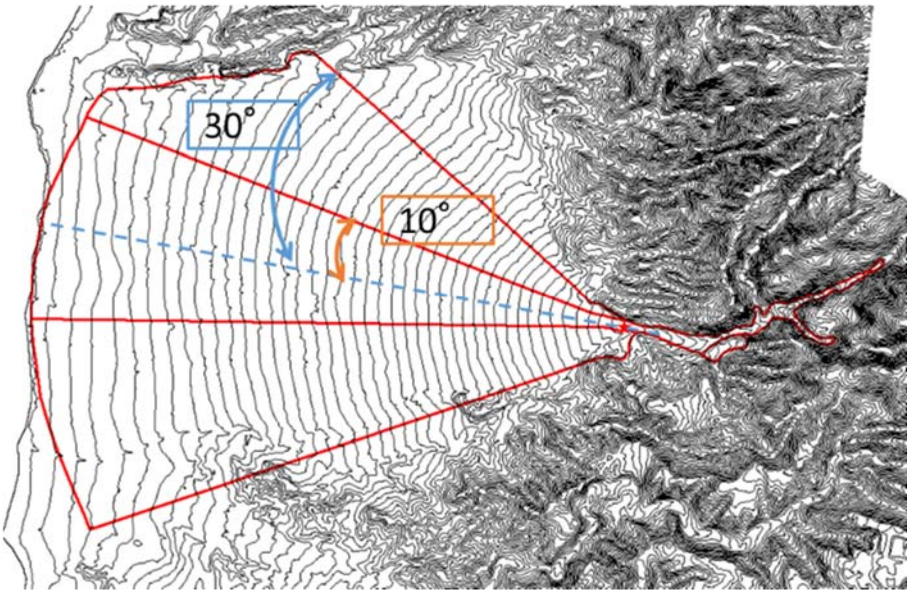
The areas where slope with 2°or more and dispersion angular with 30°or less at the point of which elevation is 5 m higher than center line shall be extracted.

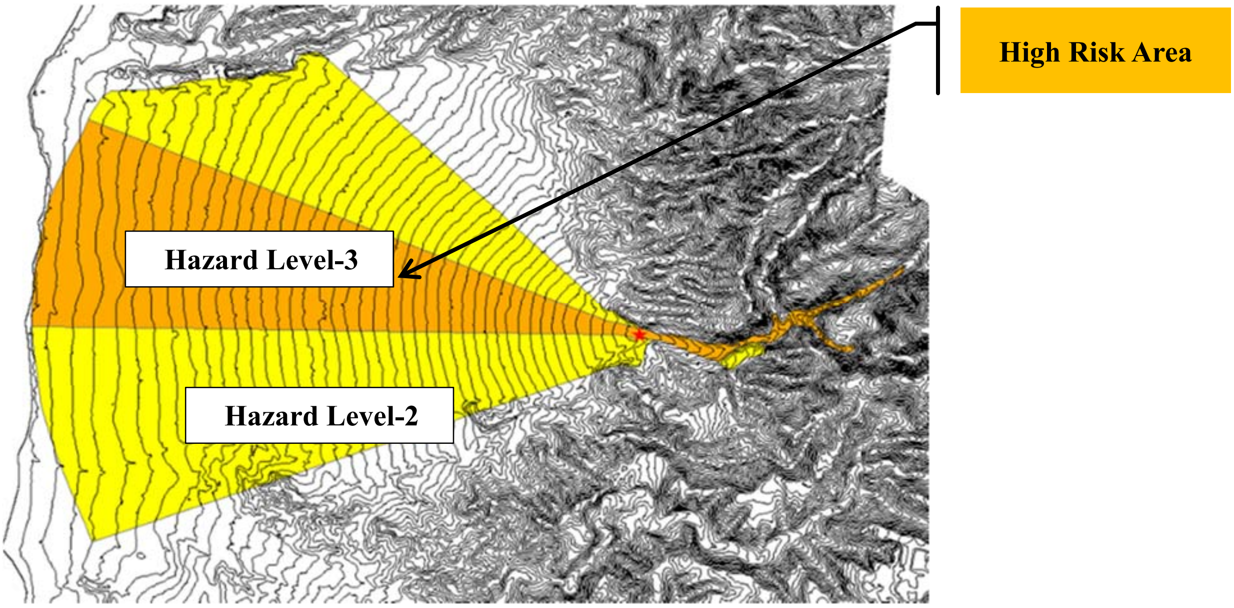


Source: JICA Expert and JICA Study Team

Figure 6-96　Method of Extracting Hazard Area (1)

The high risk areas where dispersion angular is 10°or less at the point of where elevation is 5 m higher than center line elevation shall be extracted.

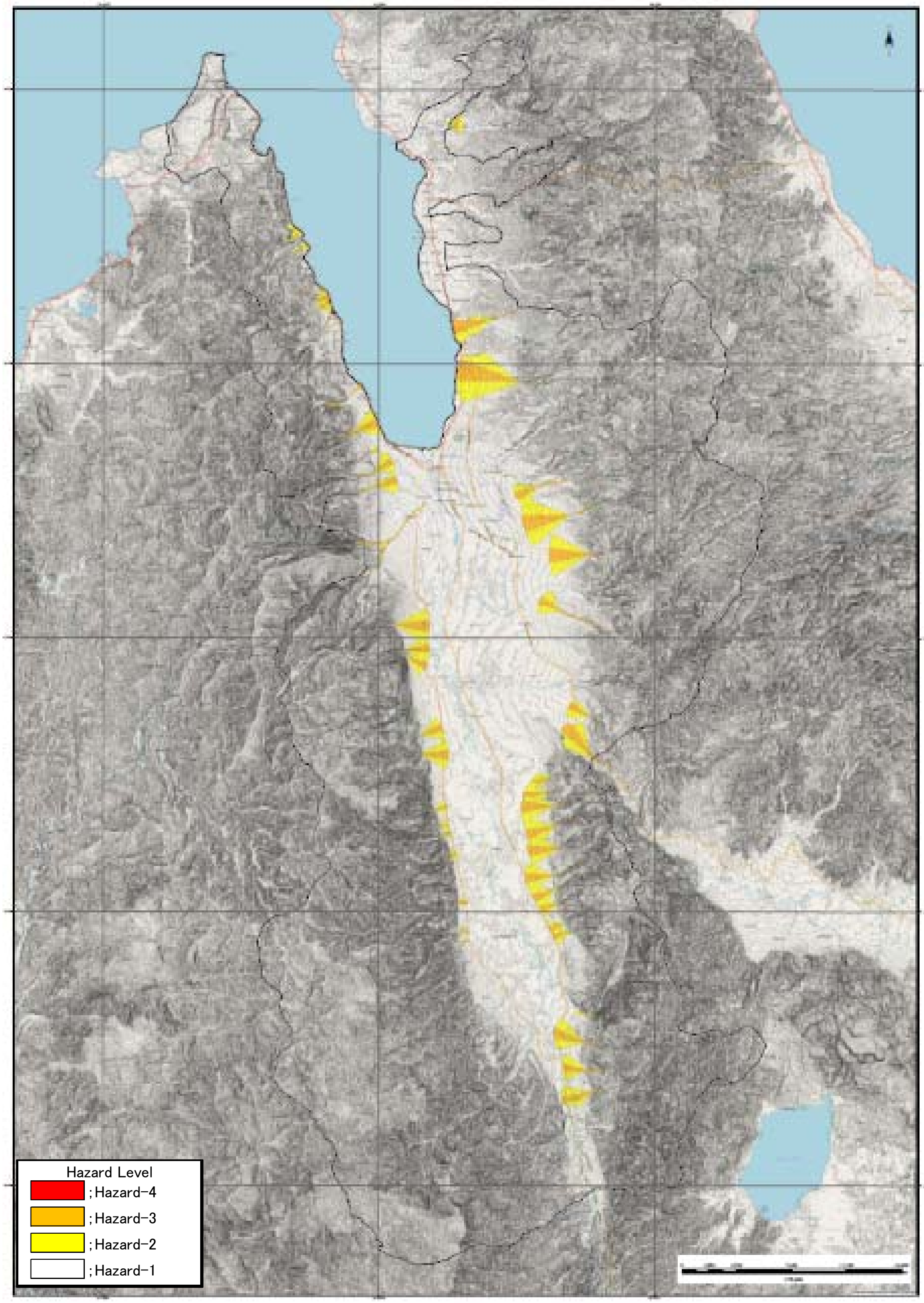




Source: JICA Expert and JICA Study Team

Figure 6-97 Method of Extracting Hazard Area (2)

The hazard map for Flash Flood (step2) is shown in the figure below.

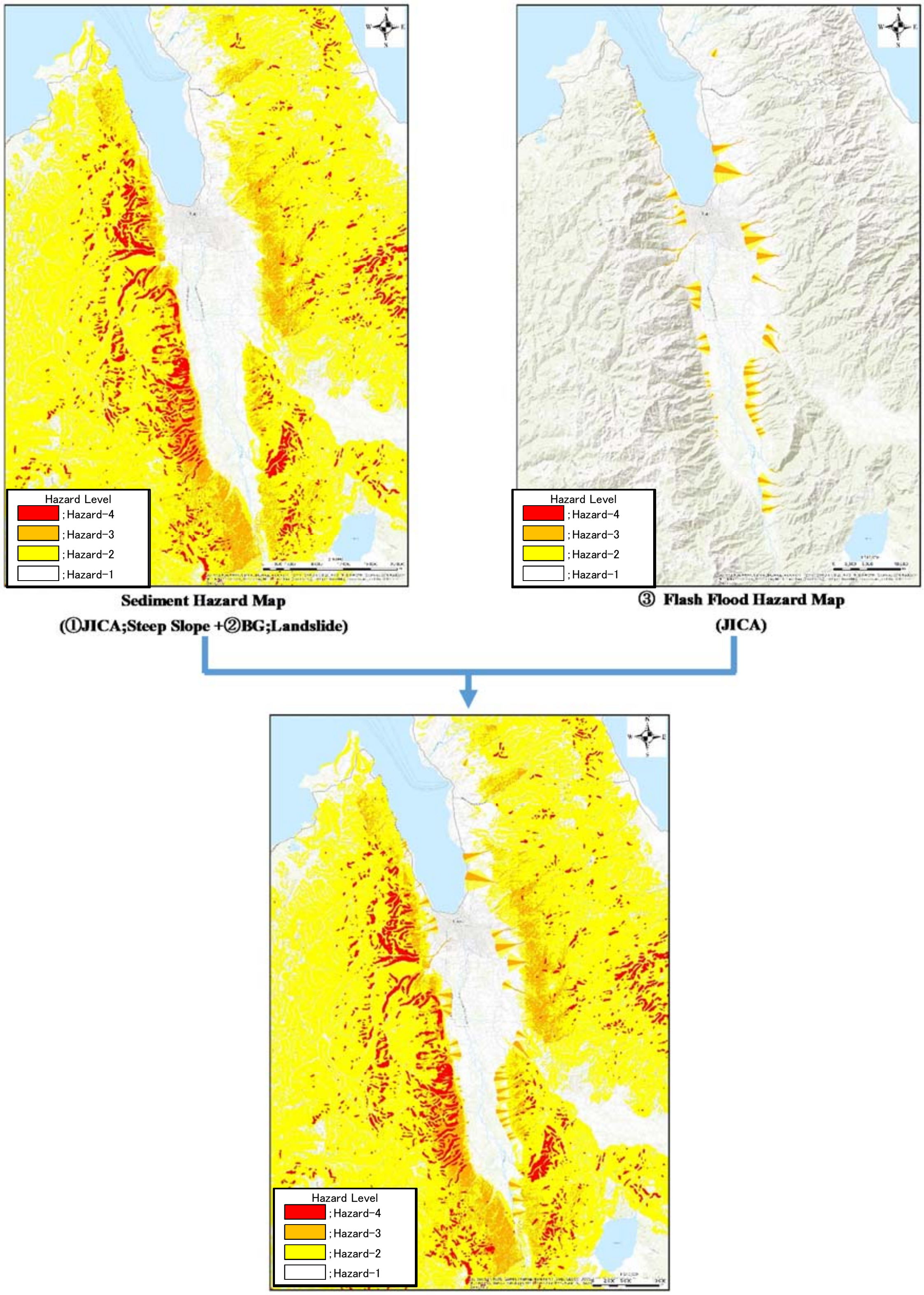


Source: JICA Expert and JICA Study Team

Figure 6-98 Hazard Map for Flash Flood (Step2)

5） Sediment Disaster Hazard Map

Finally, the hazard map about the whole sediment disaster was put together into one.



Source: JICA Expert and JICA Study Team

Figure 6-99 Sediment Disaster Hazard Map

6） Site Survey

It is important to study the history of disasters that occurred in the past in order to confirm the situation of the hazard area extracted by the above method and modify the hazard map. Here, site survey shall be conducted. The confirmation items at the site survey are shown below.

■Site survey of sediment disaster

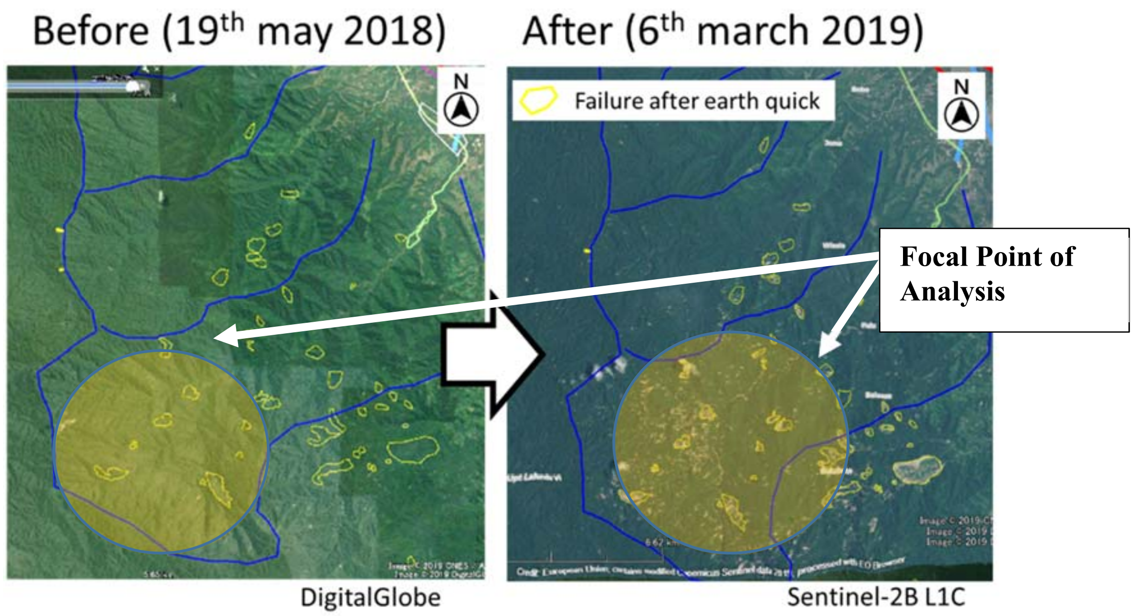
- ➢Slope, height and width of steep sloping land
- ➢Upper and lower end, left and right end of steep sloping land
- ➢Vegetation and land use of surrounding area

■Site survey of flash flood disaster

- ➢Validity of Flash Flood Starting Point
- ➢Condition of upstream the starting point such as sedimentation, bank erosion, vegetation etc.
- ➢Condition of existing measures facility for flash flood at upstream of Flash Flood Starting Point
- ➢Validity of the flow direction of Flash Flood

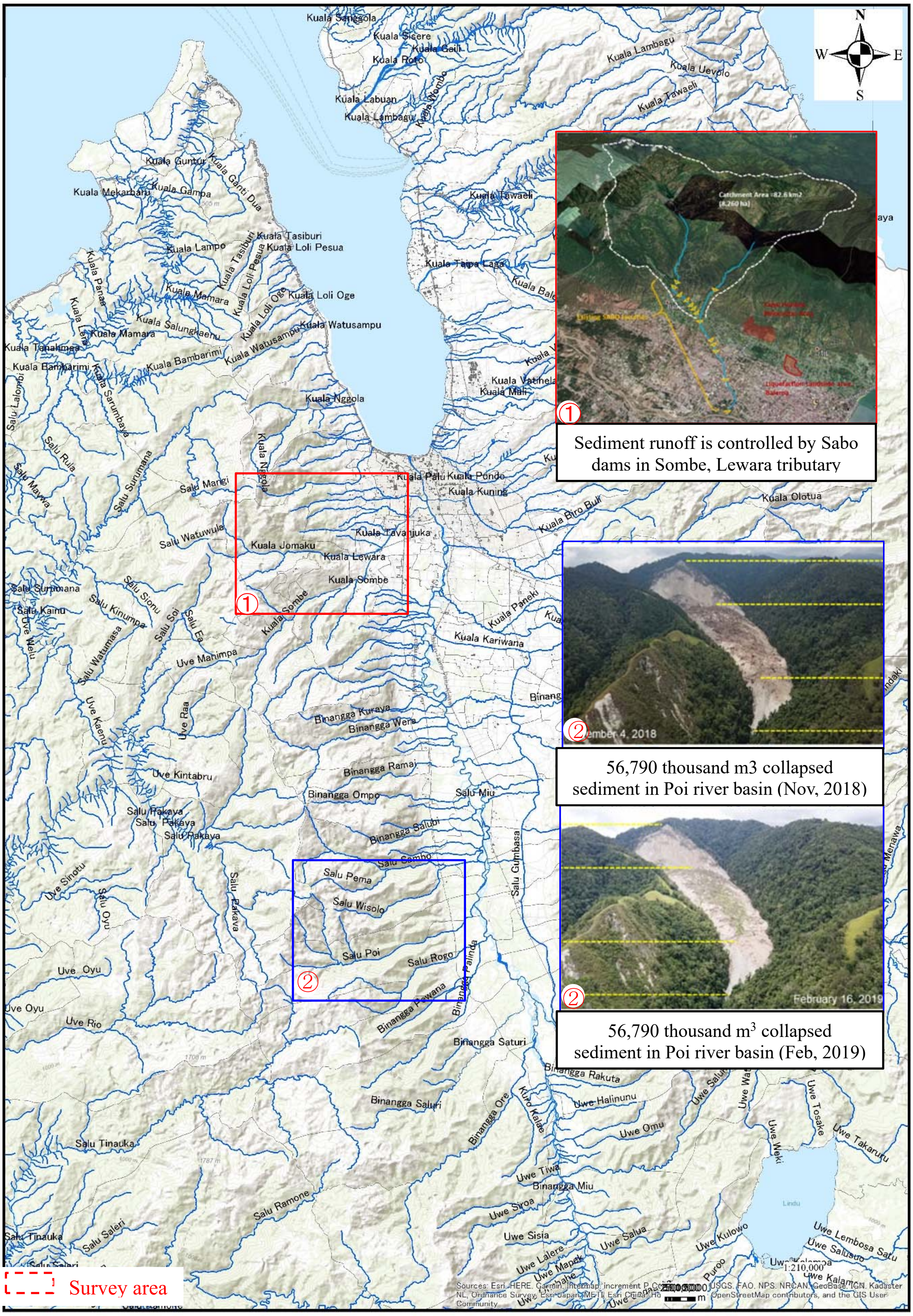
Before the site survey, the high risk areas will be confirmed by comparing the old and new satellite images. The site survey is carried out in the site and focused on locations that are confirmed by satellite images (as shown in Figure 6-100). The results of site survey are shown in Figure 6-101, Figure 6-102.

Based on these above site survey results, hazard area (steep slope collapse area, flash flood area) shall be modified.



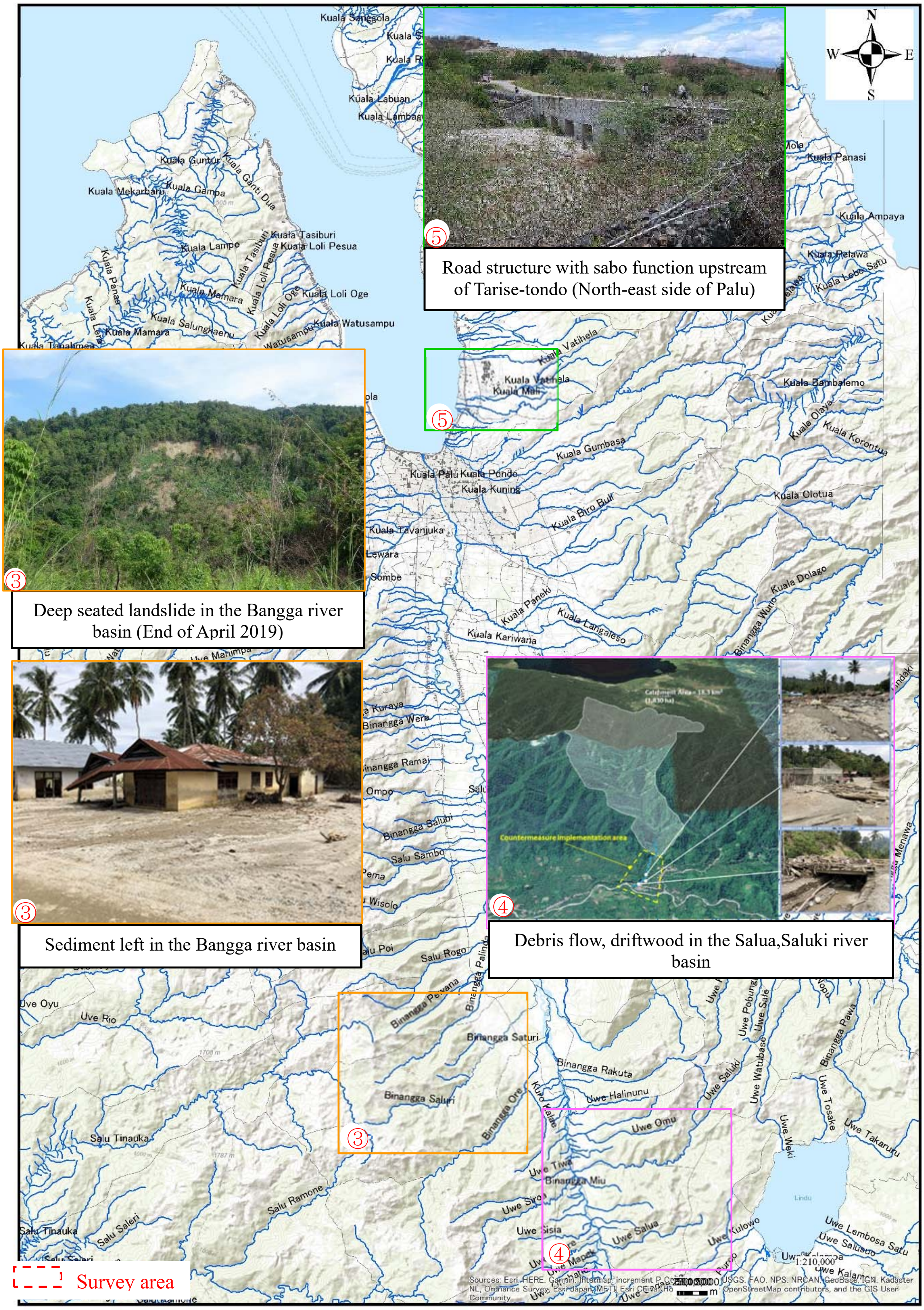
Source: JICA Study Team

Figure 6-100 Extraction of Landslides by New and Old Contrasts of satellite images (Step3)



Source: JICA Study Team

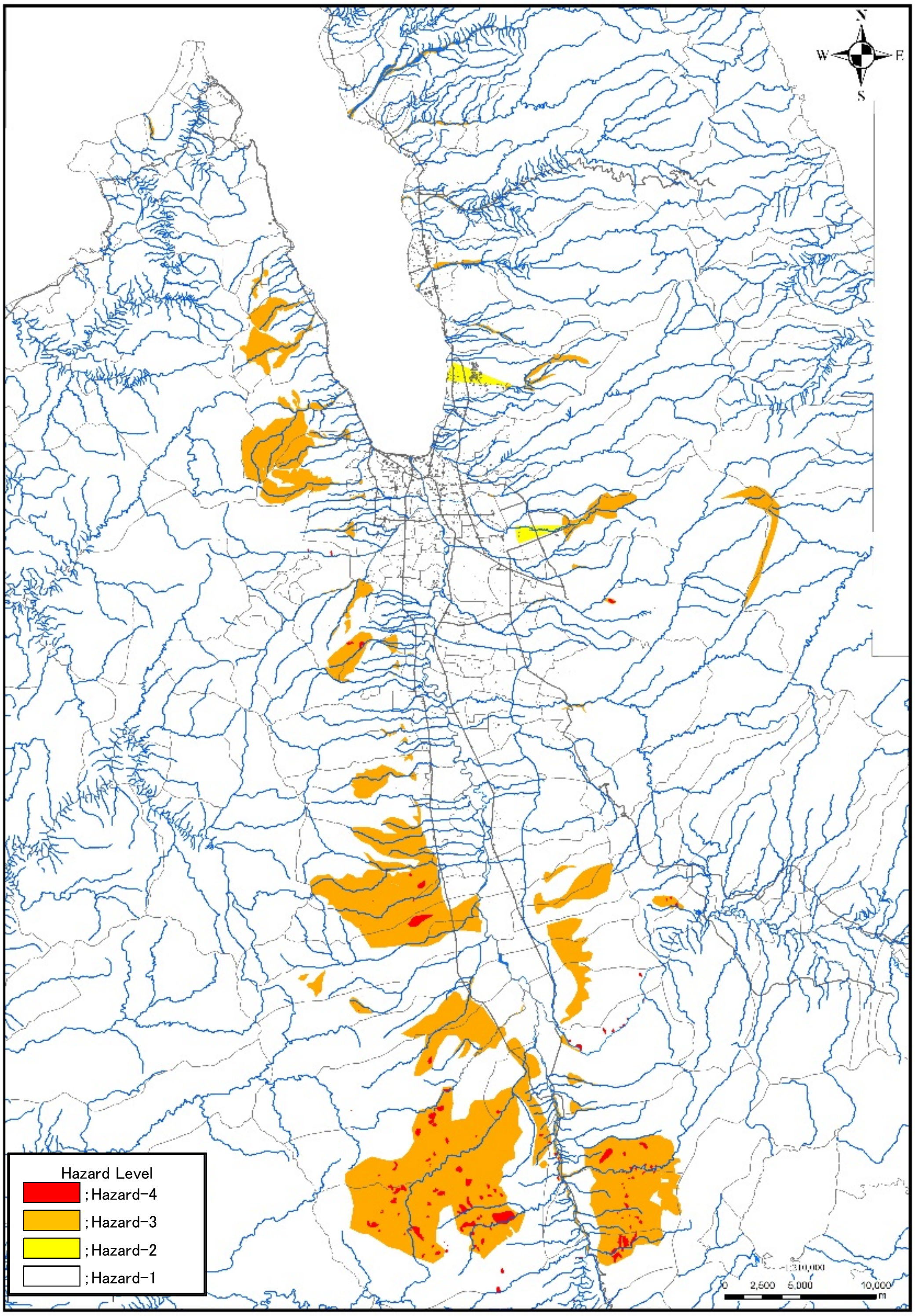
Figure 6-101 Site Survey Results (1)



Source: JICA Study Team

Figure 6-102 Site Survey Results (2)

In this site survey, the effects of disasters prevention of facilities, past disaster history and estimation of similar dangerous places are reflected as hazard level in below map.

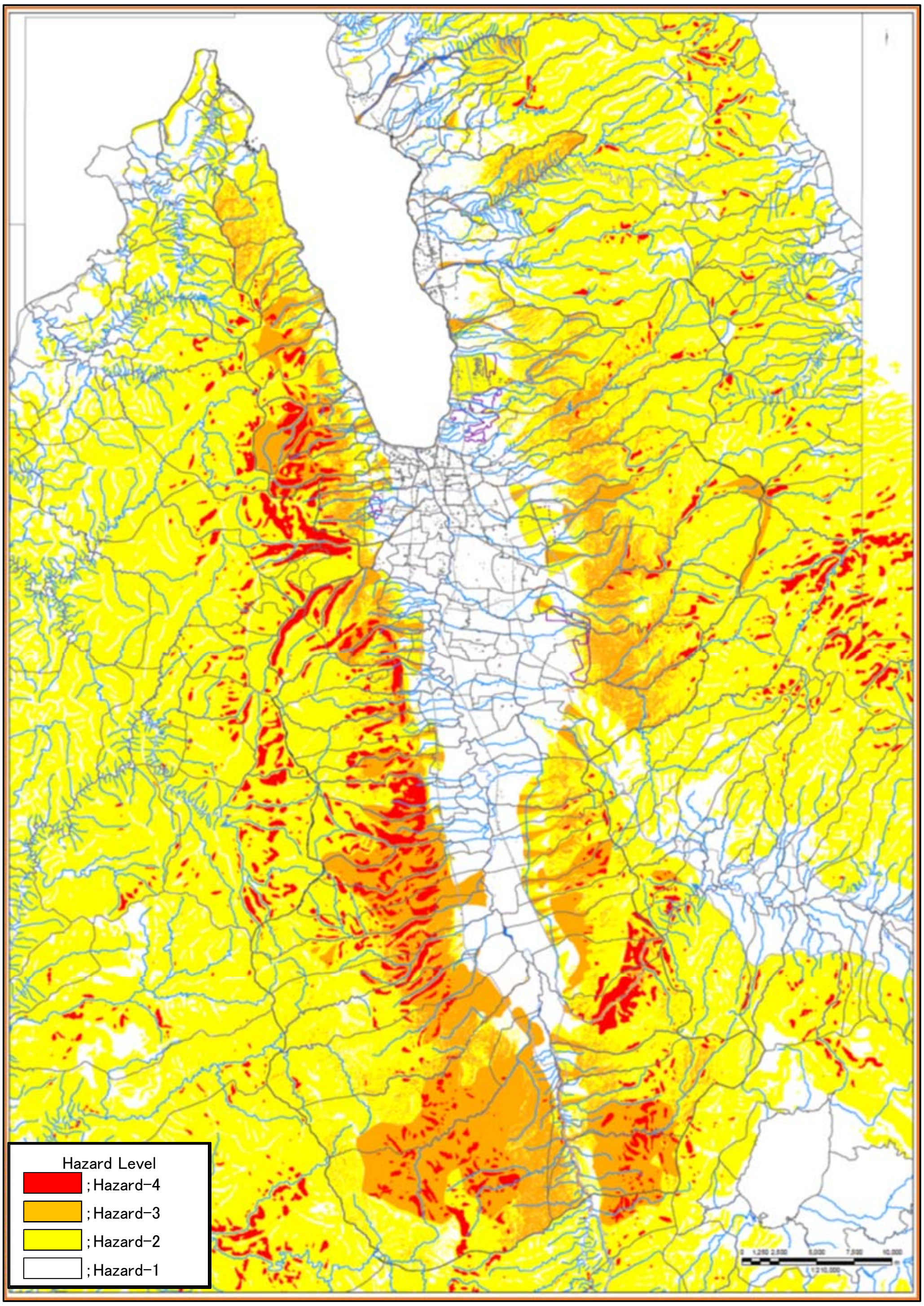


Source: JICA Expert and JICA Study Team

Figure 6-103 Risk Areas Confirmed by Site Survey

7) Reflection of Result of Site Survey in Hazard Map

Based on the site survey results, the final hazard map will be completed by combining site survey results and analyzed results. The final hazard map for steep slope collapse created by JICA Study Team is shown below.



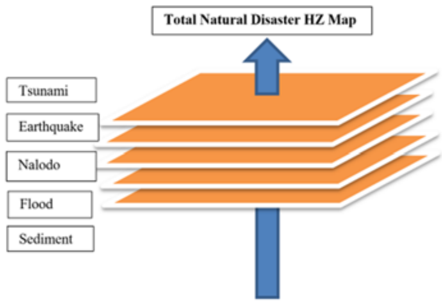
Source: JICA Expert and JICA Study Team

Figure 6-104 Sediment Disaster Hazard Map (①+②+③ ; BG+JICA)

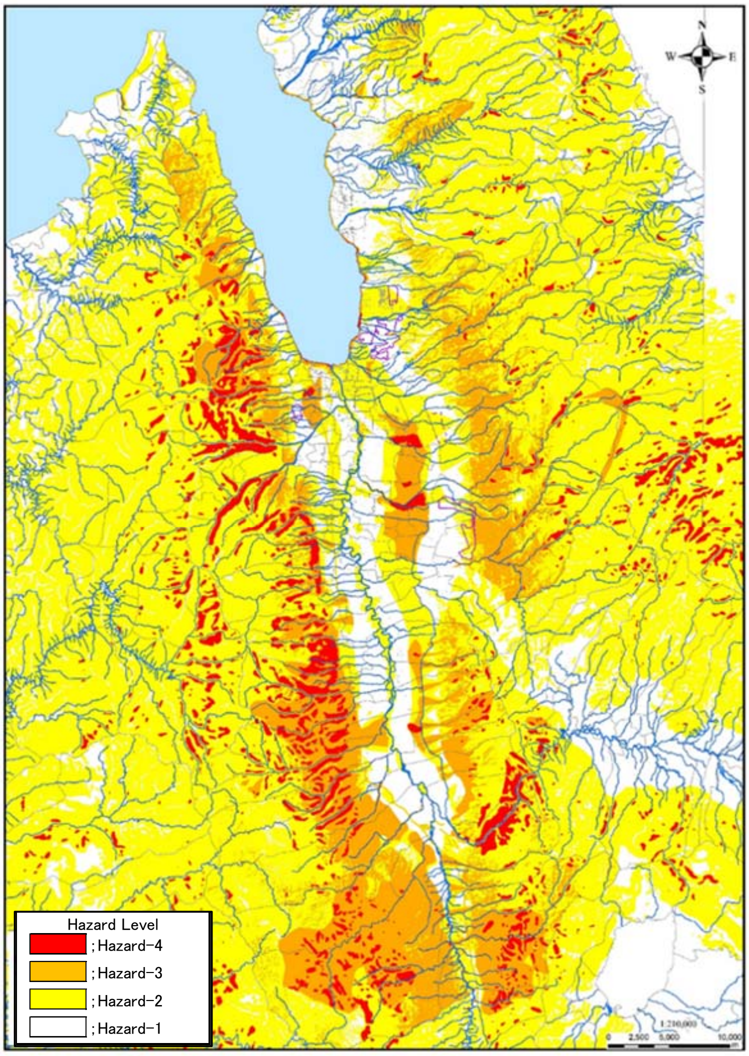
6-1-6 Integration of All Types of Disaster Hazard Map

All information and analysis results of tsunami, Nalodo, seismic, flood, and sediment disaster were organized and integrated in order to covering complex disaster hazard assessment. The image of hazard map integration is shown in Figure 6-105 and the proposed hazard map is shown in Figure 6-106.

- Tsunami
- Nalodo
  (Liquefaction landslide)
- Earthquake
- Flood
- Sediment Disaster



Source: JICA Experts and JICA Study Team
Figure 6-105 Image of Integration of Hazard Map



Source: JICA Experts and JICA Study Team
Figure 6-106 All Hazard Map (JICA Proposed)

6-1-7 Preparation of Reference Manual

The JICA Study Team prepared a reference manual to illustrate the production method of above described hazard maps, and organized it in Appendix II-1-3.

Each reference manual for five types of disaster (tsunami, Nalodo, seismic, flood and sediment disaster) were prepared. The draft reference manuals are attached in this report (refer to Appendix). In this section, the list of contents are shown in the table below.

Table 6-26 Contents of Draft Reference Manuals (Output 1)

PART I Draft Reference Manuals for Formulating Hazard Maps (Output ①)

I-1	Tsunami
I-1-1	Introduction
I-1-2	Analysis of an Outbreak Mechanism
I-1-3	Examples in history
I-1-4	Methodology of Hazard Assessment
I-1-5	Risk Reduction through Countermeasures
I-1-6	Result of Risk Assessment both of "with" and "without" Countermeasures
I-1-7	Simplified Methodology of Risk Assessment for Whole Indonesia
I-2	Nalodo (Liquefaction landslide)
I-2-1	Introduction
I-2-2	Analysis of an Outbreak Mechanism
I-2-3	Examples in history
I-2-4	Methodology of Hazard Assessment
I-2-5	Risk Reduction through Countermeasures
I-2-6	Result of Risk Assessment both of "with" and "without" Countermeasures
I-2-7	Simplified Methodology of Risk Assessment for Whole Indonesia
I-3	Earthquake
I-3-1	Introduction
I-3-2	Analysis of an Outbreak Mechanism
I-3-3	Examples in history
I-3-4	Methodology of Hazard Assessment
I-3-5	Risk Reduction through Countermeasures
I-3-6	Result of Risk Assessment both of "with" and "without" Countermeasures
I-3-7	Simplified Methodology of Risk Assessment for Whole Indonesia
I-4	Flood
I-4-1	Introduction
I-4-2	Analysis of an Outbreak Mechanism
I-4-3	Examples in history
I-4-4	Methodology of Hazard Assessment
I-4-5	Risk Reduction through Countermeasures
I-4-6	Result of Risk Assessment both of "with" and "without" Countermeasures
I-4-7	Simplified Methodology of Risk Assessment for Whole Indonesia
I-5	Sediment Disaster
I-5-1	Introduction
I-5-2	Analysis of an Outbreak Mechanism
I-5-3	Examples in history
I-5-4	Methodology of Hazard Assessment
I-5-5	Risk Reduction through Countermeasures
I-5-6	Result of Risk Assessment both of "with" and "without" Countermeasures
I-5-7	Simplified Methodology of Risk Assessment for Whole Indonesia

Source: JICA Study Team

6-2 Preparation of Hazard Maps taking Countermeasure Works into account

Hazard map should be prepared based on the condition of “before” and “after” the application or implementation of disaster prevention or reduction countermeasures for each disaster type. While the earlier II-6-1 discussed the preparation of hazard map before application or implementation of disaster prevention or reduction countermeasures, this section discusses how to prepare hazard map after application or implementation of countermeasures. However, since earthquake is commonly evaluated based on the distance from concerned active fault and although infrastructures such as road, bridge, riverbank, buildings, etc. is planned to implement disaster prevention or reduction countermeasures, disaster reduction or prevention countermeasures should not be considered for earthquake hazard level evaluation. Therefore, hazard maps of after the countermeasures implementation have been prepared only for tsunami, Nalodo, flood, and sediment disasters.

6-2-1 Structural Countermeasures

Disaster reduction and prevention countermeasures for tsunami, Nalodo, flood, and sediment disasters are categorized in structural and non-structural countermeasures. The structural countermeasures are grouped as infrastructure projects under the Output 3 plans: Tsunami countermeasures are treated by road and bridge sectors, while Nalodo, flood, and sediment disaster countermeasures are treated by river and water resource sector. Disaster prevention and reduction countermeasure development projects for each disaster type under the JICA ODA are summarized in Figure 6-107 and Figure 6-108. These countermeasure development projects only correspond to the infrastructure development projects planned under Output 3. Particularly Nalodo countermeasures should be further reviewed in details concerning groundwater monitoring, sample testing, land use planning, etc.

(1) Tsunami Countermeasures

- Target Project: A1, A2: Palu Bay Elevated Road Development Project (L = 3.6 km)
- Outline of Countermeasures

As the most effective countermeasure against higher tsunami disaster risk along the coastal line of Palu city, arterial road along the coastal line should be elevated. In order to minimize required development land use and resettlement, elevation of the road’s top surface should be minimized while allowing water overflowing. However, special structural designs are introduced such as inundation depth is set to allow evacuation of victims by themselves, building design should be regulated to reduce tsunami wave pressure, and road structural design is set to bear wave overflow power and/or movement of fault.

(2) Nalodo Countermeasures

- Target Project:
  - B1: Gumbasa Irrigation Channel Development Project (L = 6.65 km, A = 450 ha)
  - B2: Palu River upstream river improvement and sediment disaster countermeasure

development project as well as groundwater monitoring technical assistance project (this will be a combined project with flood and sediment countermeasure project summarized in the following item 3)

- B18 : Nalodo Reduction and Prevention Countermeasure Project (Balaroa, Petobo, Jono Oge, Sibalaya: total 380 ha)

➢ Outline of Countermeasures

In the earlier section, the occurrence mechanism of Nalodo was identified to be highly complicated and further continuous research and study are necessary to understand the mechanism. Through the technical assistance project under JICA ODA, groundwater level has been recognized as one of the important causes of Nalodo, according to the survey and research. Thus, several countermeasures are considered to reduce Nalodo occurrence risks: 1) Application of tight water proof sealing to Gumbasa irrigation channel structure which may become water supply to groundwater system; 2) Installation of water wells to reduce high pressurized pore water away during earthquake occurrence; 3) Decrease the river bed elevation by river improvement project; and 4) Maintain the groundwater level at certain level (for instance less than 3 m in depth) in the areas of alluvial fan damaged land with managing irrigation system water use in good condition.

(3) Flood and Sediment Disaster Countermeasures

Flood and sediment disaster countermeasures are packaged as a target project as summarized below.

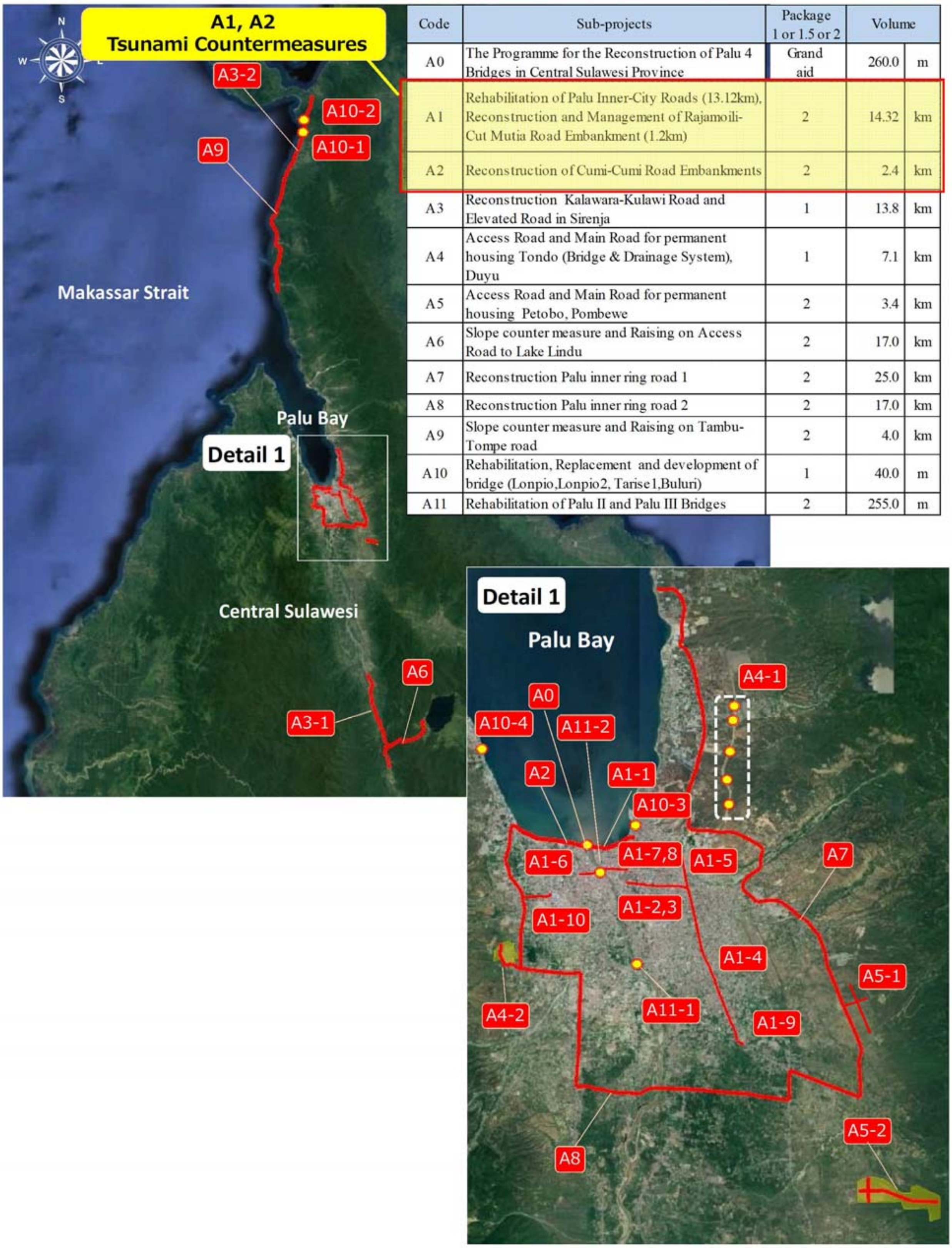
➢ Target Project:

- B2~B5, B12~B14, B17: Palu River and its tributary rivers improvement and countermeasure construction projects

➢ Outline of Countermeasures

For flood control countermeasure, river flow capacity improvement such as construction works of riverbed dredging, river widening, and retention pond or reservoir development for peak flow control, stabling river bed slope, and others, is considered as an integrated countermeasure.

For sediment disaster countermeasure, flash flood control, and sediment flow control, construction works of sabo dam, improvement of river bed and river section, and sand pocket development to temporary control sediment outflow are planned for countermeasures.



Code	Sub-projects	Package 1 or 1.5 or 2	Volume	
A0	The Programme for the Reconstruction of Palu 4 Bridges in Central Sulawesi Province	Grand aid	260.0	m
A1	Rehabilitation of Palu Inner-City Roads (13.12km), Reconstruction and Management of Rajamoili-Cut Mutia Road Embankment (1.2km)	2	14.32	km
A2	Reconstruction of Cumi-Cumi Road Embankments	2	2.4	km
A3	Reconstruction Kalawara-Kulawi Road and Elevated Road in Sirenja	1	13.8	km
A4	Access Road and Main Road for permanent housing Tondo (Bridge & Drainage System), Duyu	1	7.1	km
A5	Access Road and Main Road for permanent housing Petobo, Pombewe	2	3.4	km
A6	Slope counter measure and Raising on Access Road to Lake Lindu	2	17.0	km
A7	Reconstruction Palu inner ring road 1	2	25.0	km
A8	Reconstruction Palu inner ring road 2	2	17.0	km
A9	Slope counter measure and Raising on Tambu-Tompe road	2	4.0	km
A10	Rehabilitation, Replacement and development of bridge (Lonpio,Lonpio2, Tarise1,Buluri)	1	40.0	m
A11	Rehabilitation of Palu II and Palu III Bridges	2	255.0	m

Source: JICA Study Team

Figure 6-107 Tsunami Countermeasure Projects

Code	Sub-projects	Package 1 or 1.5 or 2	Volume	
B1	Improvement of Gumbasa Main Channel, Improvement of secondary, tertiary, drainage channels, and paddy field recovery	2	6.7	km
B2	Capacity Development of the Surface and Groundwater Monitoring (including telemetry system), River Improvement and Sediment control (Up stream of Palu River)	2	1	Set
B3	River Improvement and Sediment control in Poi River	1	1	Set
B4	River Improvement and Sediment control in Bangga River	1	1	Set
B5	River Improvement and Sediment control in Salua River	1	1	Set
B6	River Improvement and Sediment control in Miu River	1.5	1	Set
B7	River Improvement and Sediment control in Namo River	1.5	1	Set
B8	River Improvement and Sediment control in Kalawi River	1.5	1	Set
B9	River Improvement and Sediment control in Omu River	1.5	1	Set
B10	River Improvement and Sediment control in Tuva River	1.5	1	Set
B11	Polder System Pilot Project in Lende Sirenja Village	1.5	1	Set
B12	River Improvement (Down stream of Palu River considering tsunami countermeasures), River Improvement and Sediment control(Middle stream of Palu River)	2	1	Set
B13	River Improvement and Sediment control in Paneki River (Down Stream)	1	1	Set
B14	River Improvement and Sediment control in Paneki River (Middle Stream, Nalodo Area)	2	1	Set
B15	River Improvement and Sediment control in Lewara River	2	1	Set
B16	River Improvement and Sediment control in Poboya River	2	1	Set
B17	River Improvement and Sediment control(Middle stream of Palu River and Tributary)	2	1	Set
B18	Countermeasure for Liquefaction-Landslide areas (Balaroa, Petobo, Jono Oge, Sibaraya)	2	380.0	ha
B19	Flood and sediment disaster countermeasures against relocation areas (Tondo, Duyu, Petobo, Ponbewe district)	2	1	Set

Code	Sub-projects	Package 1 or 1.5 or 2	Volume	
C1	Reconstruction of Anutapura Hospital	2	1	Set

Source: JICA Study Team

Figure 6-108 Nalodo Countermeasure and Flood/Sediment Disaster Countermeasure Projects

6-2-2 Non-structural Countermeasures

Implementation of non-structural countermeasures together with structural countermeasures is important in order to reduce disaster damages. Non-structural countermeasures include shelter development, secure appropriate evacuation route, evacuation warning system, evacuation guidance, evacuation plan, disaster prevention education and drill, etc. Implementation and operation of non-structural countermeasures should be made by good cooperation and collaboration between local government and people/community in order to reduce disaster damages and risks. Assistance in the project only suggested the importance of the non-structural countermeasure implementation. Therefore, the hazard map considered of countermeasures does not includes non-structural countermeasures.

Recommended non-structural countermeasures to be implemented in the assistance project target areas are listed below.

(1) Tsunami

Besides planning the elevated road development as a structural countermeasure for tsunami disaster, non-structural (soft) countermeasures should also be implemented considering the risks of greater impact of tsunami. Non-structural countermeasures for tsunami disaster risk reduction mainly incorporate planning and installation of early warning system and shelter facility. In particular, tsunami data collection, analysis and evaluation of tsunami, and information transmission method are important to plan the early warning system in detail. When evacuation plan is produced, the plan should carefully set by considering topographic information (altitude) of land where shelter facility to be planned, evacuation route, required evacuation time, infectious disease countermeasures, etc.

- Tsunami Early Warning System Development
- Preparation of Evacuation Plan

(2) Nalodo

Several countermeasures are considered to reduce Nalodo occurrence risks: 1) Application of tight water proof sealing to Gumbasa irrigation channel structure which may become water supply to groundwater system; 2) Installation of water wells to reduce high pressurized pore water away during earthquake occurrence; 3) Decrease of riverbed elevation by river improvement project; and 4) Maintain groundwater level at certain level (for instance less than 3 m in depth) in the areas of alluvial fan damaged land with managing irrigation system water use in good condition. Among these countermeasures, point 4) is considered for rehabilitation of damaged irrigation system and restoration of local agro-industry that was common industrial activity in the damaged areas. However, this could be a major negative cause for disaster risk reduction as the irrigation system might charge groundwater whereas groundwater level control is essential. Due to this concern, open trench construction of the irrigation channel should be carefully planned and designed with water tight concrete sealing as a structural countermeasure together with introduction of water gates and drainage network system. Such integrated irrigation system is highly desired with proper groundwater management system and organization packaged with automated water gate and groundwater level monitoring. While considering above countermeasures, the collaboration between ADB (other donor) who is also assisting the same irrigation rehabilitation and reconstruction feasibility study and master planning, and JICA Study Team has organized a coordination meeting to identify effective recommendation with BBB concept.

- Development of groundwater management system and groundwater management organization, and installation of early warning system

(3) Flood and Sediment Disaster Countermeasures

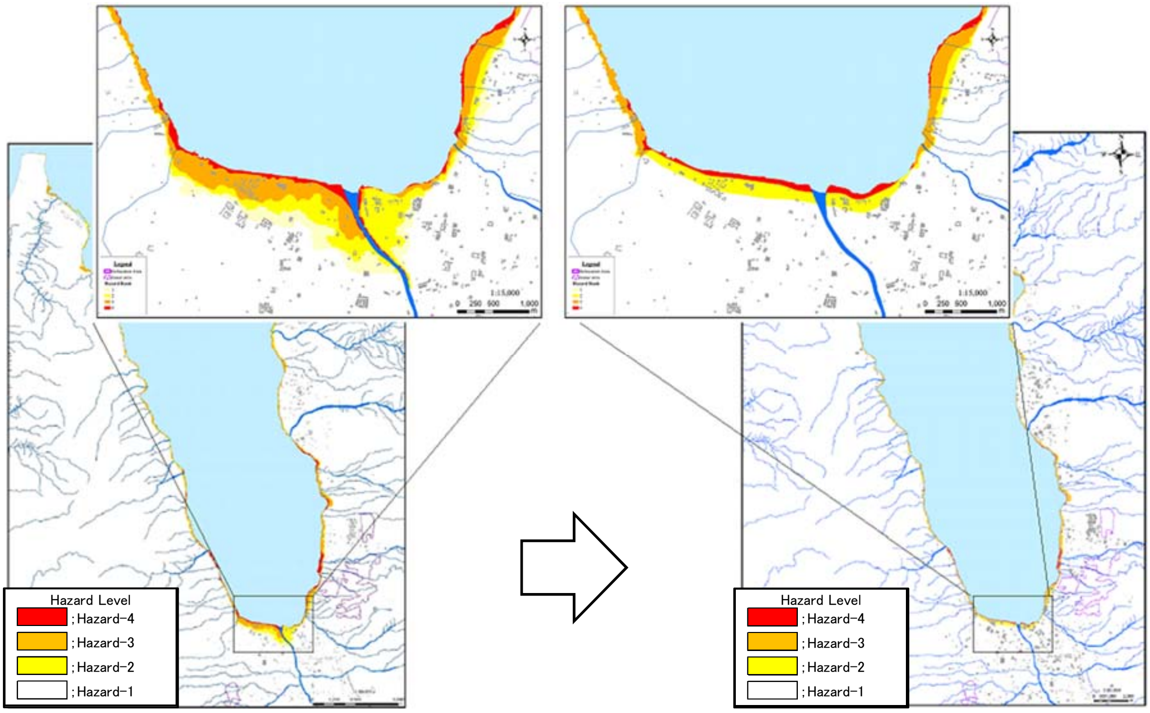
River channel maintenance, retention pond or reservoir development, Sabo facility development, etc. are considered for flood control and sediment disaster countermeasure. Non-structural countermeasures (soft countermeasures) together with these structural countermeasures are highly necessary. Particularly, early warning system and shelter facility planning and installation are very important as soft countermeasures for flood and sediment disaster risk reduction. Rainfall data collection, flood analysis, sediment disaster analysis and information transmission method are necessary for detailed study of early warning system planning. When evacuation plan is developed, the plan should carefully consider topographic information (altitude) of land where shelter facility to be planned, evacuation route, required evacuation time, infectious disease countermeasures, etc.

- Flood and Sediment Disaster Early Warning System Development
- Preparation of Evacuation Plan

6-2-3 Preparation of Hazard Map incorporating Countermeasures

(1) Tsunami Hazard Map (after countermeasure installation)

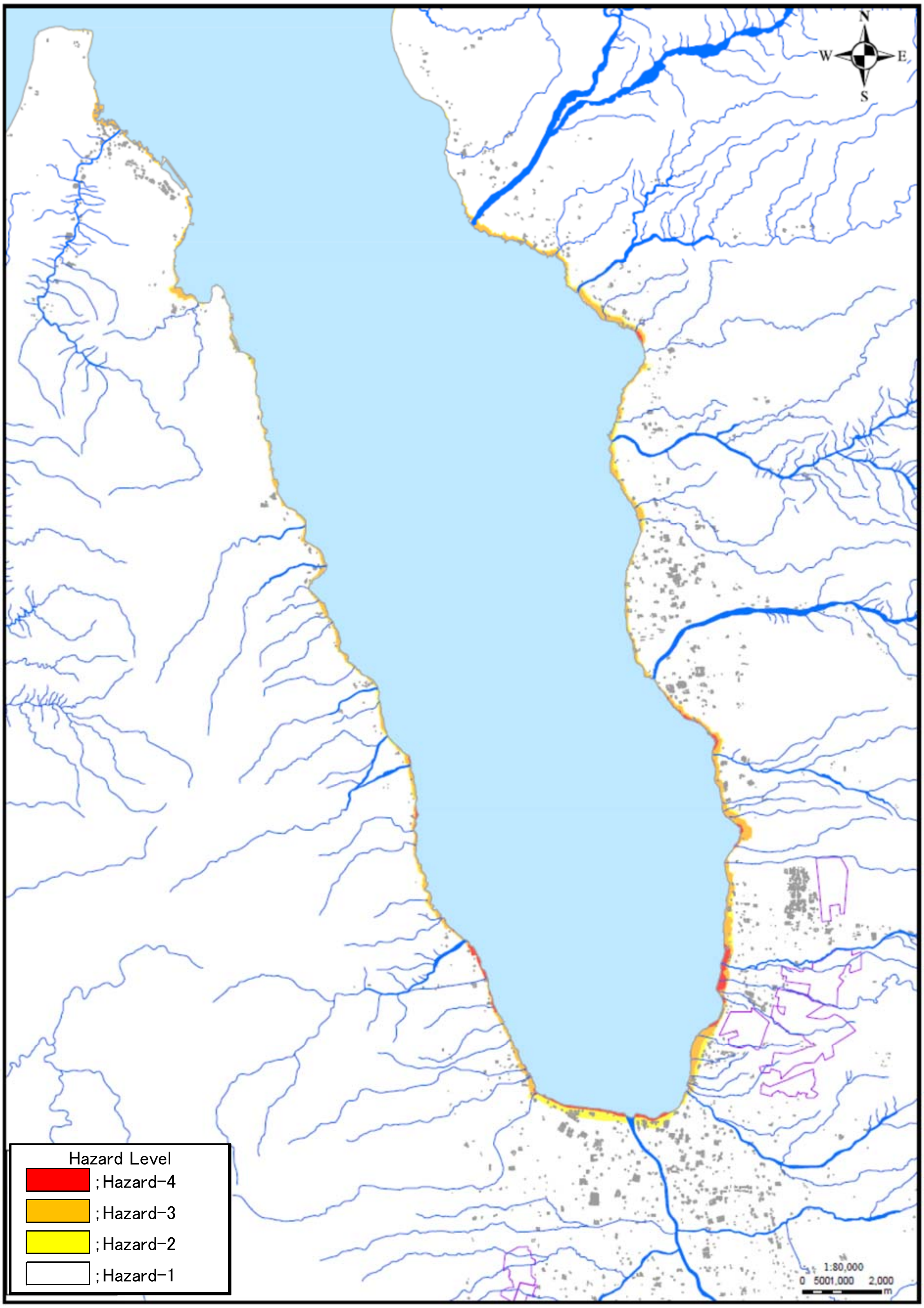
The effect of tsunami damage reduction by elevated road structure as planned above has been evaluated by applying tsunami value simulation. The simulation result indicates that the inundation depth of inland side area of the planned elevated road is less than 1 m, which is equal to the hazard level 2. Based on this simulation result, tsunami hazard map before and after the countermeasure work installation is established (Figure 6-109).



Source: JICA Experts and JICA Study Team

Figure 6-109 Tsunami Hazard Map before and after Countermeasure
(Left: before countermeasure, Right: after countermeasure installation)

In order to assess the effective of the above planned risk reduction countermeasures, the tsunami hazard map had been created in considering the effectiveness of countermeasures by numerical tsunami simulation. The tsunami hazard map with countermeasures shown as follows.

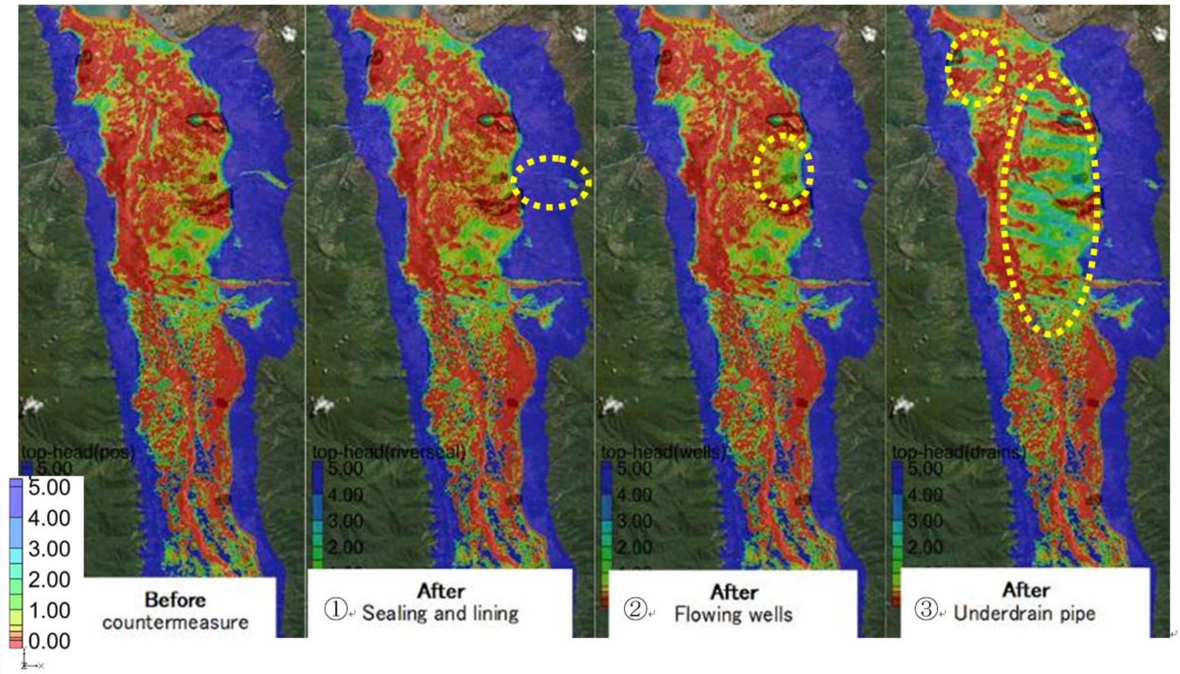


Source: JICA Expert and JICA Study Team

Figure 6-110 Tsunami hazard map with countermeasures

(2) Nalodo Hazard Map (after countermeasure installation)

The effect of Nalodo damage risk reduction has been evaluated using groundwater level model analysis by considering the structural countermeasures for Nalodo, i.e. 1) sealing for irrigation channel, 2) artesian well and wells, and 3) culvert drainage. The model analysis result indicated that the groundwater level after the countermeasure installation was lowered about 2 to 3 m deep. The result is shown in Figure 6-111 (yellow dotted circles indicates the location with good effect of countermeasure).



Source: JICA Experts and JICA Study Team

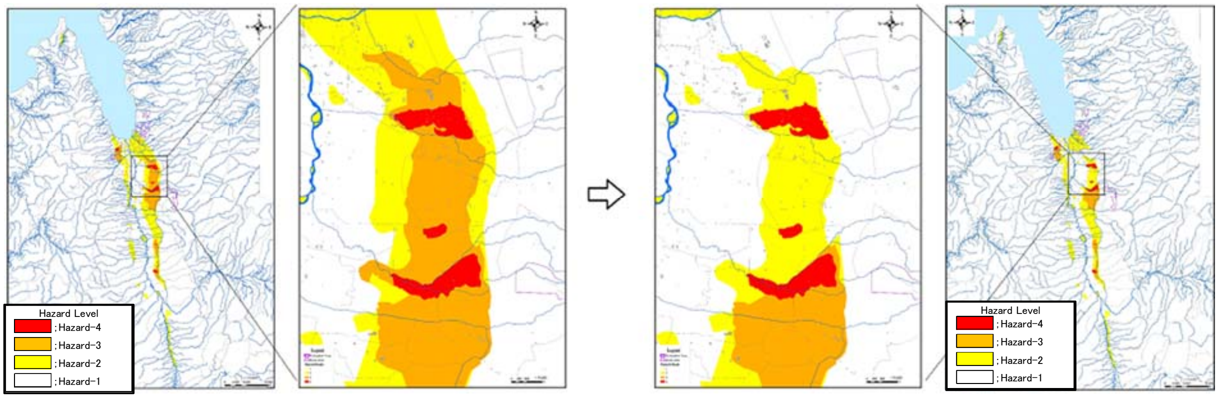
Figure 6-111 Target Area Groundwater Level Analysis Result

Hazard level after countermeasure installation is set in accordance with the following condition.

Nalodo damage has largely occurred in the areas where the following five (5) causes exists: 1) shallow groundwater level; 2) sloped land; 3) loose sandy layer deposits; 4) presence of pressurized groundwater; and 5) presence of permeable layer. However, many other causes aside from the five mention above, and Nalodo mechanism is not fully explained yet. Therefore, the hazard map before countermeasure installation was prepared with hazard criteria based on the magnitude of disaster damage (variation of ground movement).

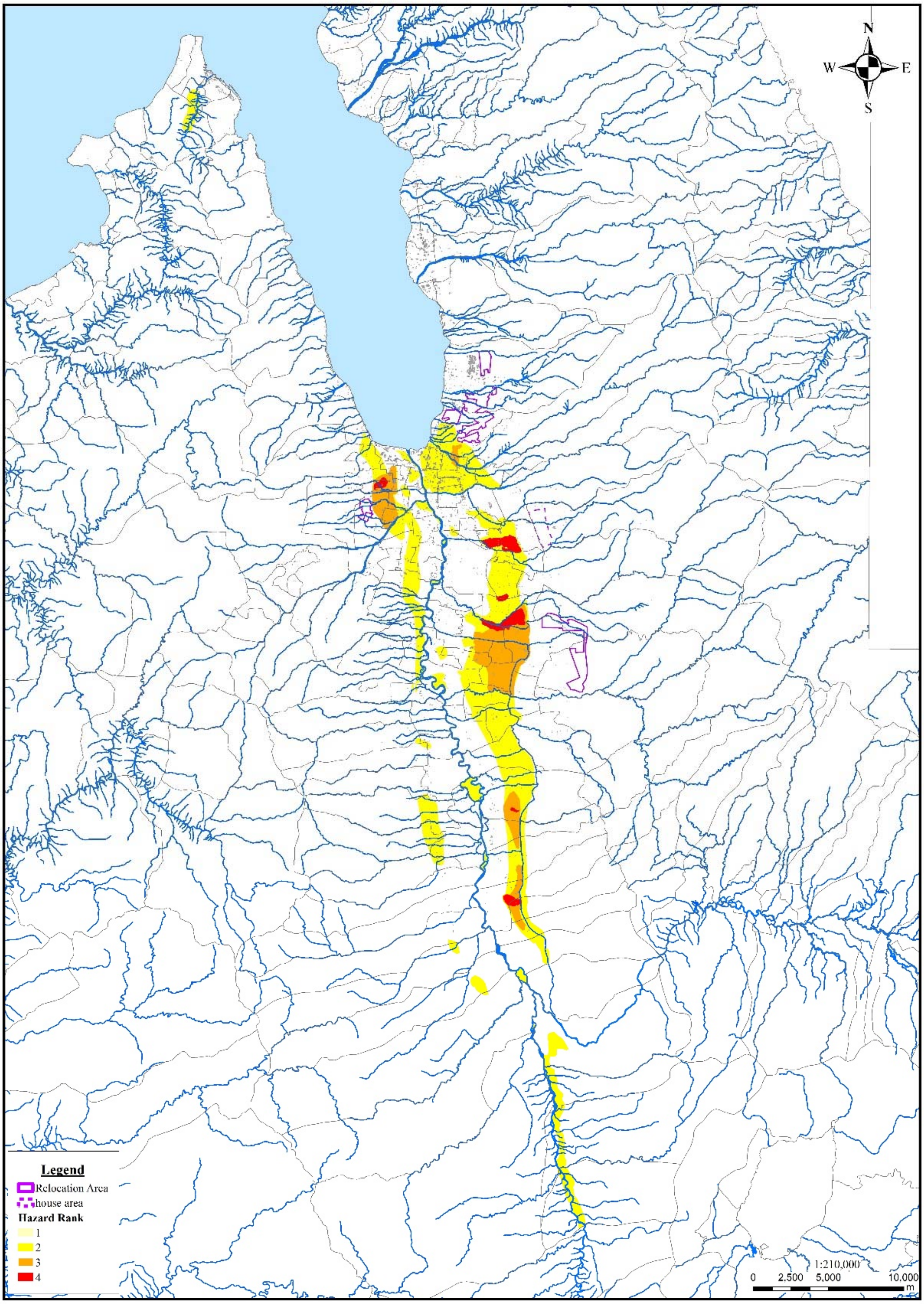
For the five causes above, the recommended countermeasure are 1) lowering groundwater level and 4) reduce pressurized pore water (out of above five causes). However, implementation of soil improvement for causes number 2), 3) and 5) would cost very high. Lowering groundwater level could contribute local area risk reduction and safety improvement (reduce liquefaction potential). While implementing high-pressure pore water dissipation work to the areas where high pressure pore water has been identified due to the earthquake, would be highly effective. However, since other potential causes of Nalodo could exist, hence the hazard level should be reduced one (1) rank lower than that of before countermeasure installation. Nalodo hazard maps before and after countermeasure installation are shown in Figure 6-112.

The areas with hazard level 4 was largely damaged by the earthquake, and the risk of next disaster occurrence could increase when cap layer is recovered. Therefore, the hazard level for these area was not changed.



Source: JICA Experts and JICA Study Team

Figure 6-112 Nalodo Hazard Maps before and after Countermeasures

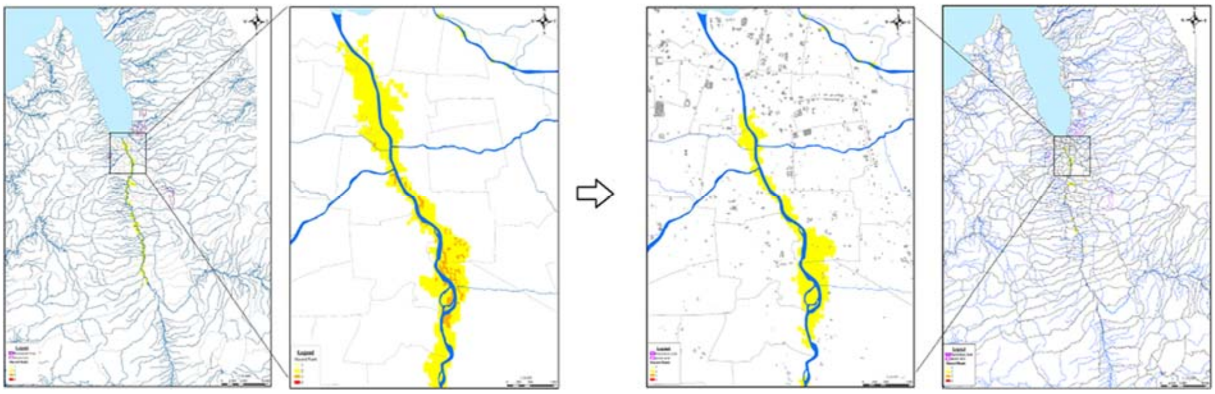


Source: JICA Expert and JICA Study Team

Figure 6-113 Nalodo hazard map with risk reduction countermeasures

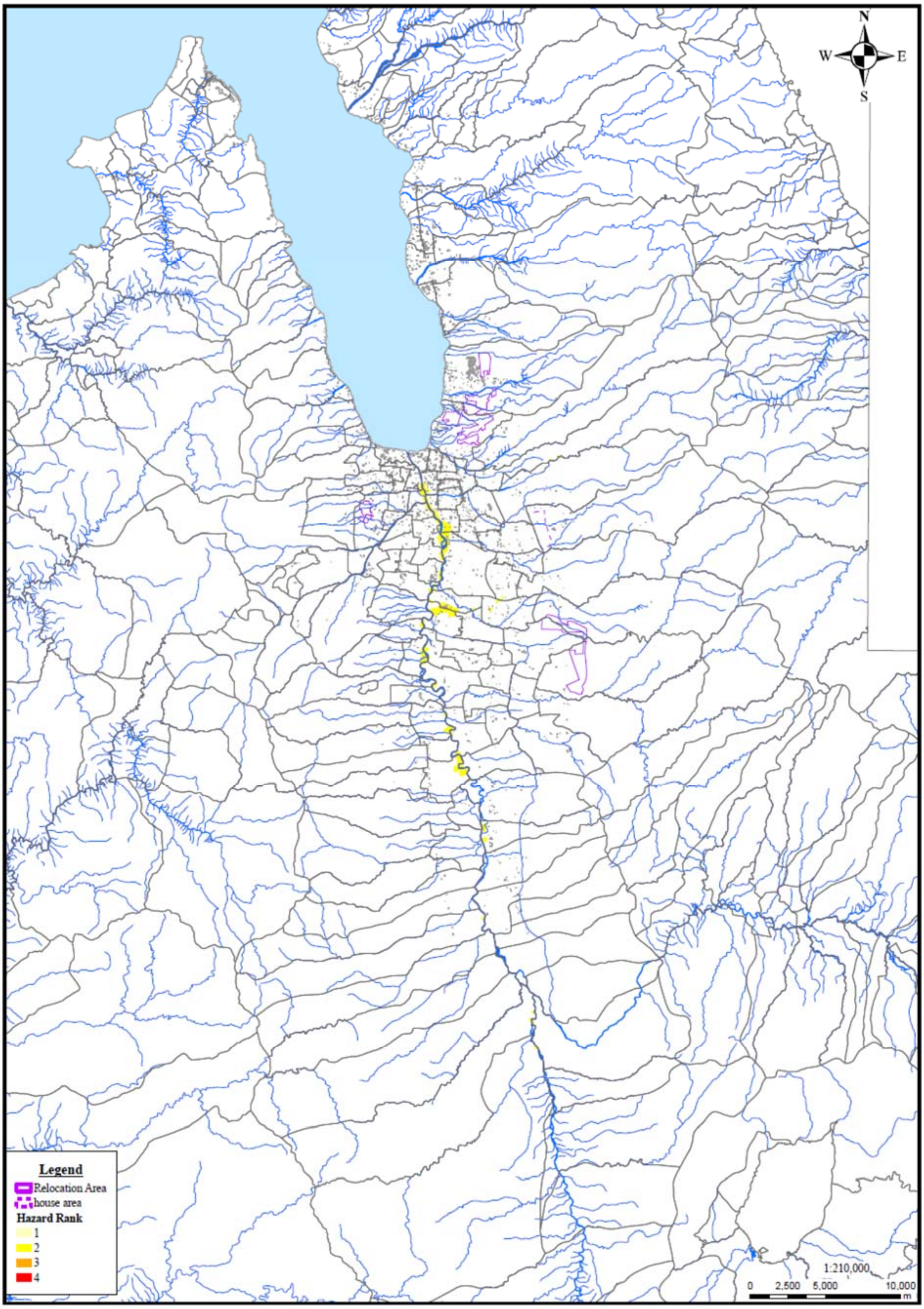
(3) Flood Hazard Map (after countermeasures installation)

Flood damage reduction effect based on the river dredging or bank enlargement as described earlier has been evaluated by flood analysis applying RRI modeling. The result indicates that flood and inundation cannot be fully prevented but inundation depth and area could be largely reduced. Based on this flood analysis result, flood hazard maps before and after countermeasure installation (refer to Figure 6-114). In addition, risk map before and after countermeasure installation has also been prepared to evaluate economic damage and human damage.



Source: JICA Experts and JICA Study Team

Figure 6-114 Flood Hazard Maps before and after Countermeasures

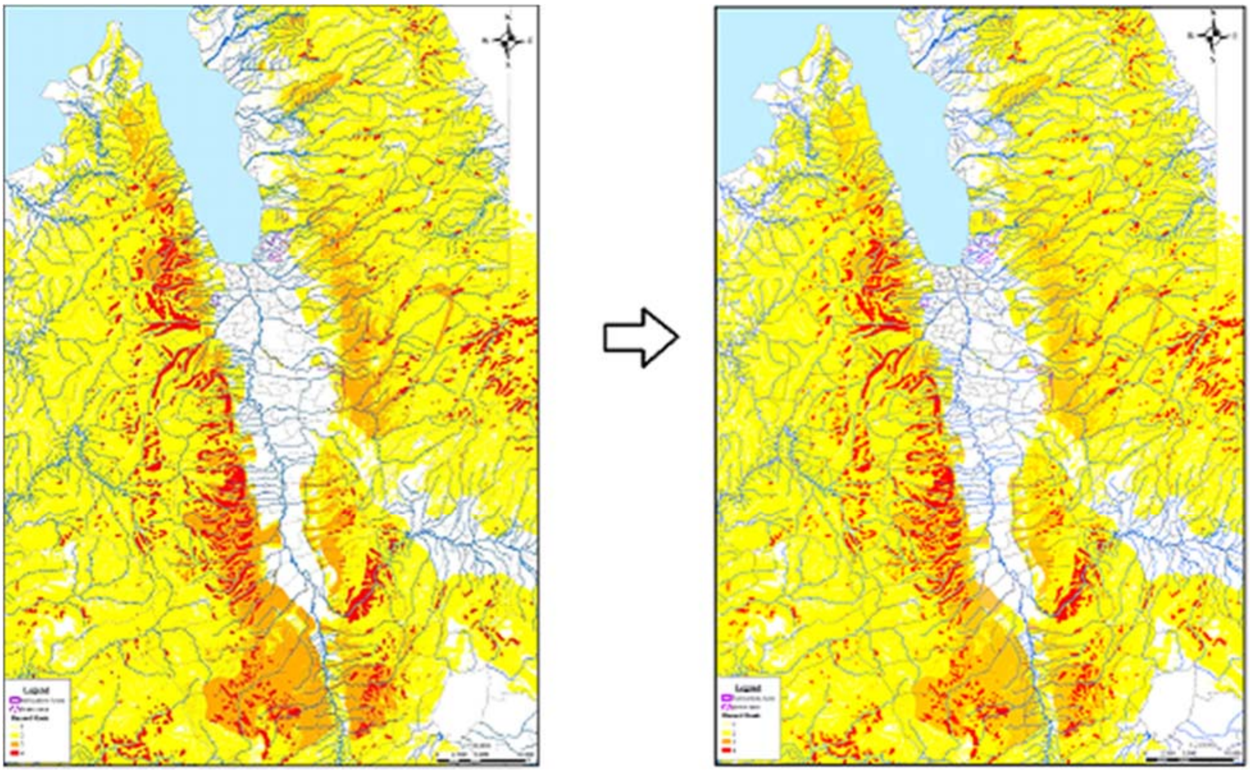


Source: JICA Expert and JICA Study Team

Figure 6-115 Flood hazard map with countermeasures

(4) Sediment Disaster Hazard Map (after countermeasures installation)

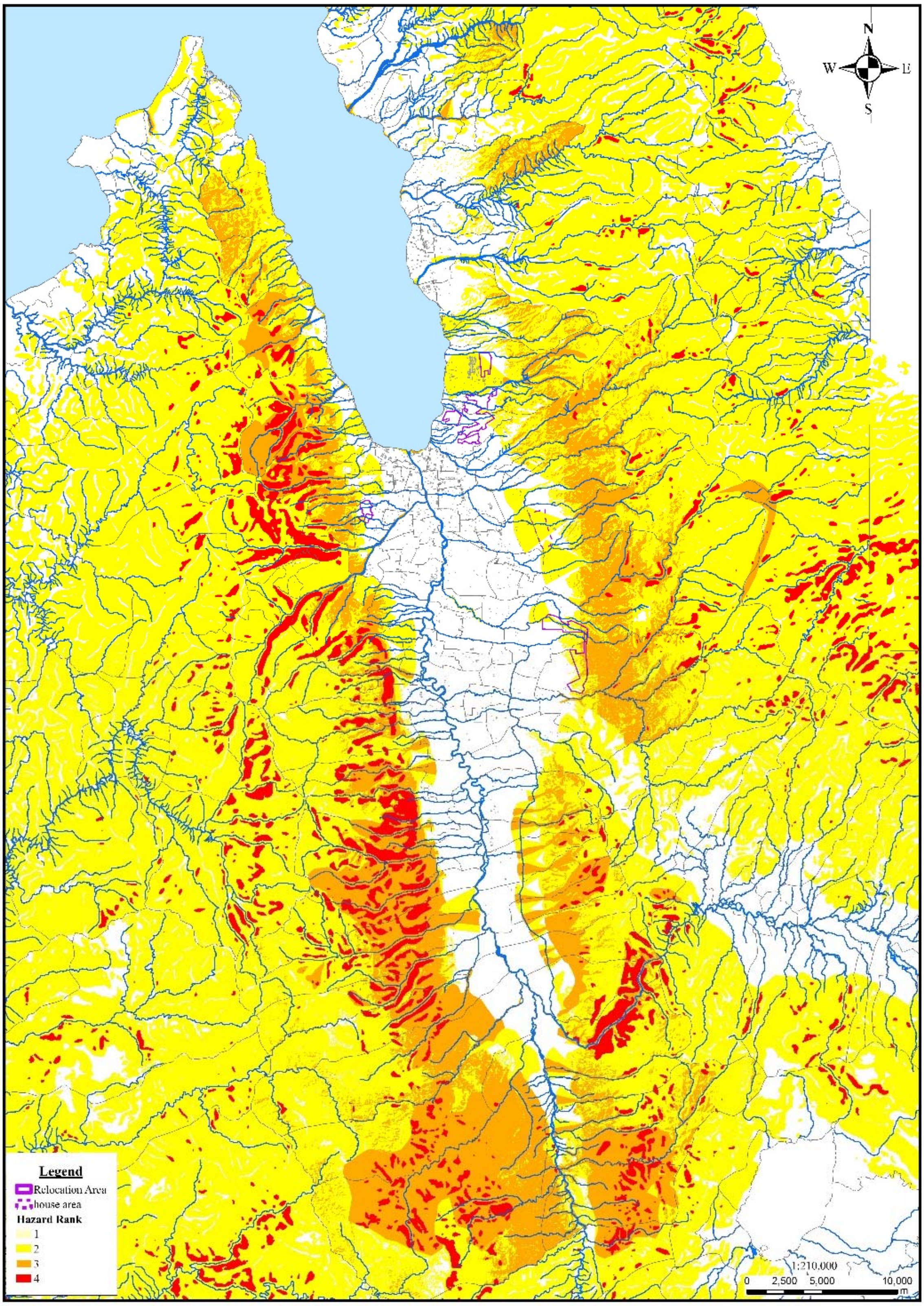
Sabo dam and drainage channel have been planned for sediment disaster countermeasures as described earlier. After these countermeasures are developed, sediment outflow should be well controlled in target areas, and sediment disaster hazard level of downstream side should be reduced by one (1) rank. Sediment disaster hazard maps before and after countermeasure installation are illustrated in Figure 6-116.



Source: JICA Experts and JICA Study Team

Figure 6-116 Sediment Disaster Hazard Maps before and after Countermeasures

Sediment hazard map has been created when the above planed risk reduction countermeasures taken. The hazard map with countermeasures is shown as below



Source: JICA Expert and JICA Study Team

Figure 6-117 Sediment hazard map with countermeasures

6-3 Risk Map and Reference Manual Preparation

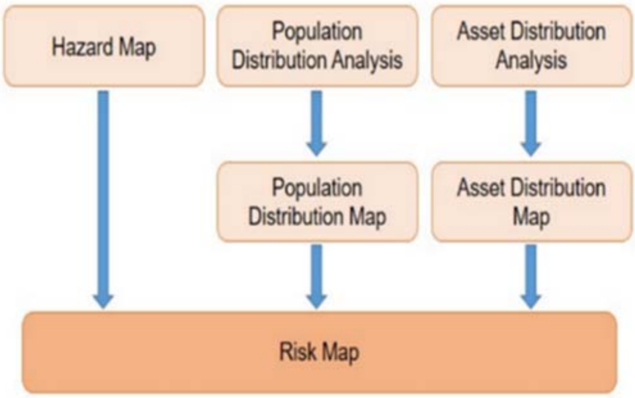
According to ATR's request, the Study Team has prepared Risk Map and Reference Manual for risk map production urgently, although it was immediately after the disaster occurrence. The Risk Map was produced in the original condition (without countermeasures) in order to identify high-risk areas. The map was utilized to evaluate disaster risk reduction effectiveness for each countermeasure.

6-3-1 Risk Map Production

(1) Outline

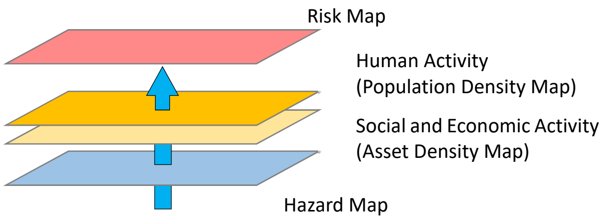
When typical risk map is produced, multiple data such as disaster risks, urban condition, assets, etc., are collected and comprehensively analysed from the viewpoint of structural characteristics, vulnerability, evaluation priority, etc. to check their asset value. The assistance project was directly after the disaster occurrence with urgent demand. With that reasons and considering flexibility for future update, the Study Team has made recommendation that hazard map and population map (easy to obtain) and asset distribution map (30 m mesh) were used in order to produce a risk map for each disaster type (tsunami, Nalodo, earthquake, flood, and sediment disaster). (Refer to Figure 6-119 and Figure 6-118)

The production method of the recommended Risk Map is summarized in Figure 6-120.



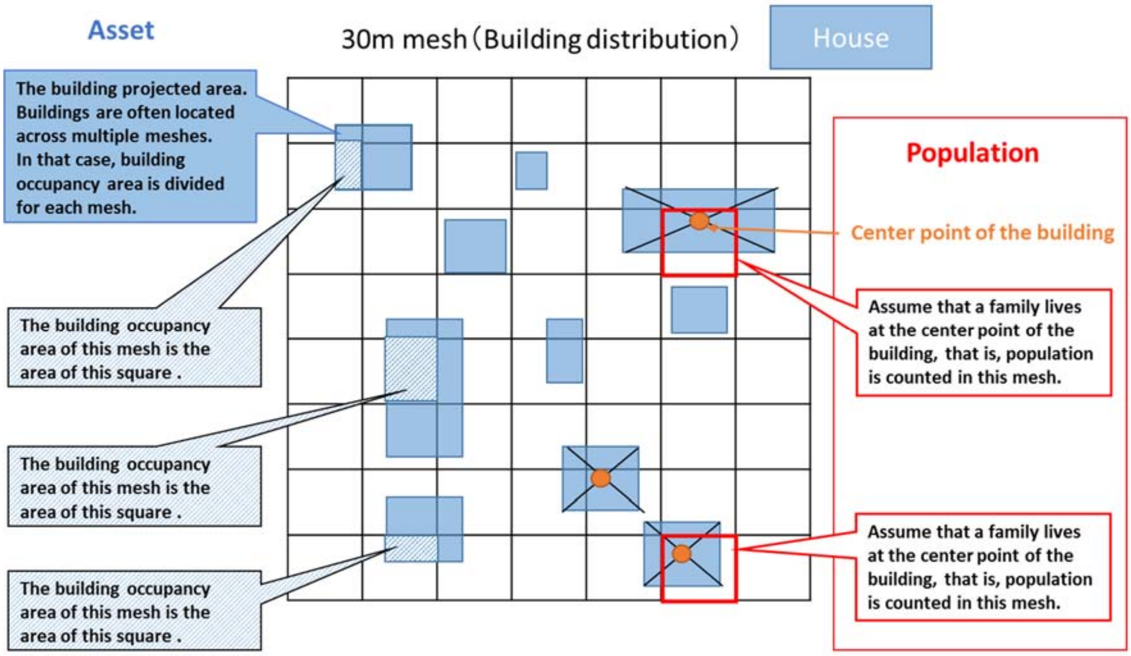
Source: JICA Expert and JICA Study Team

Figure 6-119 Integration of Risk Maps



Source: JICA Expert and JICA Study Team

Figure 6-118 Risk Map Production Flow



Source: JICA Expert and Study Team

Figure 6-120 Population and Asset Distribution Map Production Flow

a) Steps for creating the population distribution map

① Ground and 1st floor is assumed as residential use, and pick up applicable buildings

② Set center point of selected building

③ Set average household population of four (4) to the building center point located mesh

b) Steps for creating the asset distribution map production step

① Identify building profile

② Calculate total floor area of the building located in a mesh

③ Calculate asset value multiplying total floor area in each mesh with building unit price (300 Million IDR/m^2)

c) Risk evaluation method

Disaster risk has been evaluated using human risk score and asset risk score. Population risk score is based on the evaluation of human life loss at the time of possible disaster occurrence, while asset risk score is based on asset loss at the time of possible disaster occurrence. Where hazard score is high, potential of disaster occurrence is high. Therefore, hazard score is multiplied with either population risk score or asset risk score in order to calculate and evaluate both population and asset disaster risks (Figure 6-121).

- Population Risk Score (P)＝【Hazard Score ①×Human Life Loss Score ②】
- Asset Risk Score (A)＝【Hazard Score ①×Asset Loss Score ③】

When population and asset risk scores are high, it indicates that the area has higher risk and there is a need for development of disaster risk reduction countermeasure. In order to evaluate overall comprehensive disaster risk, the described population risk and asset risk above should be added as 1:1 ratio (both risk scores are considered equal value without any weighting) under the project.

- Comprehensive Disaster Risk ＝【Population Risk Score＋Asset Risk Score】

When/if more detailed data could be obtained in the future, score weighting may be rearranged.

Calculation method of Risk Score

Hazard Score①	Population score②	Asset Score③	Risk Score (①×②)+(①×③)
4	0.0 ~ 2.0	0.0 ~ 2.0	**0.0 ~ 16.0**
3			**0.0 ~ 12.0**
2			**0.0 ~ 8.0**
1			**0.0**

※Population risk score shall be set "0" where no one is living, and shall be set "1.0~2.0" where 1 or more people live.

Source: JICA Experts and JICA Study Team

Figure 6-121 Risk Score Calculation Method

In this project, hazard and human life are prioritized for disaster risk evaluation. However, final risk level (extremely high risk, very high risk, high risk, etc.) setting has been finalized through the discussion with ATR (refer to Figure 6-122).

Risk Point	Risk Level
15.0 ~16.0	
14.0 ~ 15.0	
13.0 ~ 14.0	
12.0 ~ 13.0	
11.0 ~ 12.0	
10.0 ~ 11.0	
9.0 ~ 10.0	
8.0 ~ 9.0	
7.0 ~ 8.0	
6.0 ~ 7.0	
5.0 ~ 6.0	
4.0 ~ 5.0	
3.0 ~ 4.0	
2.0 ~ 3.0	
1.0 ~ 2.0	
0.0 ~ 1.0	

RLt≧ 8.0 ･････ Risk is extremely high

RLt≧ 6.0 ･････ Risk is very high

RLt≧ 3.0 ･････ Risk is high

RLt≧ 2.0 ･････ Risk is medium

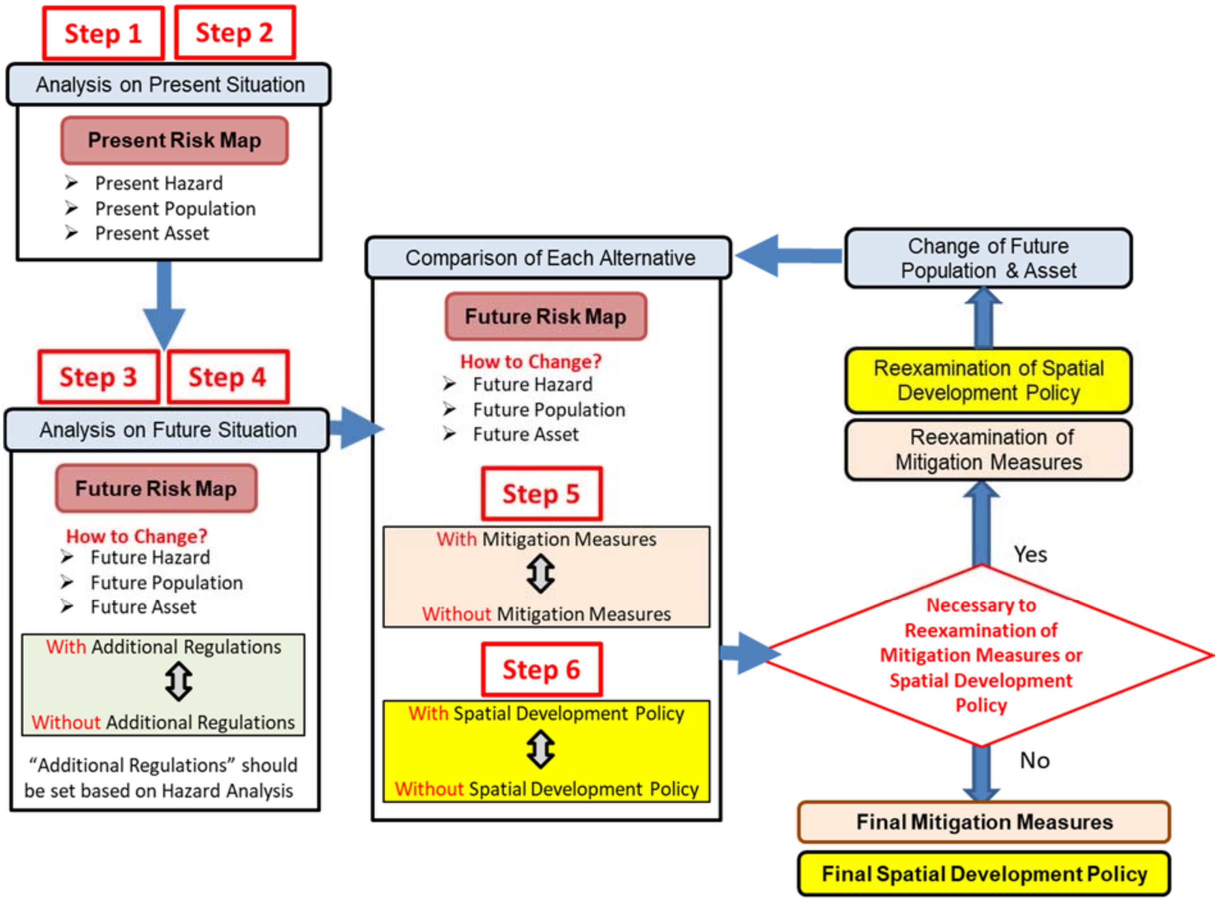
Rl t≧ 0.0 ･････ Risk is low

Source: JICA Experts and JICA Study Team

Figure 6-122 Evaluation of Risk Point and Risk Level

Disaster risk map should be created to improve our understanding of disaster risk to vraulnerable communities and properties resulting from exposure to hazards as previously mentioned. Especially, it is important to evaluate disaster risk to hazard-prone areas for disaster management, mitigation measures and spatial development policy making purposes. In particularly, risk evaluation should be used to estimate how much risk would be reduced after each mitigation measures. Through the comparison of risk between *with* and *without* situation, the best mitigation measures should be selected. Moreover, based on the selected mitigation measures, the best of spatial structure should be modified to adapt the disaster risk. If necessary for checking, spatial development policy should be revised. The modified population and asset based on the revised spatial development policy should be input into the future risk analysis. The flow of disaster risk reduction analysis with mitigation measures and spatial development policy is shown in Figure 6-123.

Risk evaluation was implemented based on the conditions of the hazards, population, and assets (buildings) of each area. The risk map was prepared to evaluate risk in urgent after a disaster occurred.

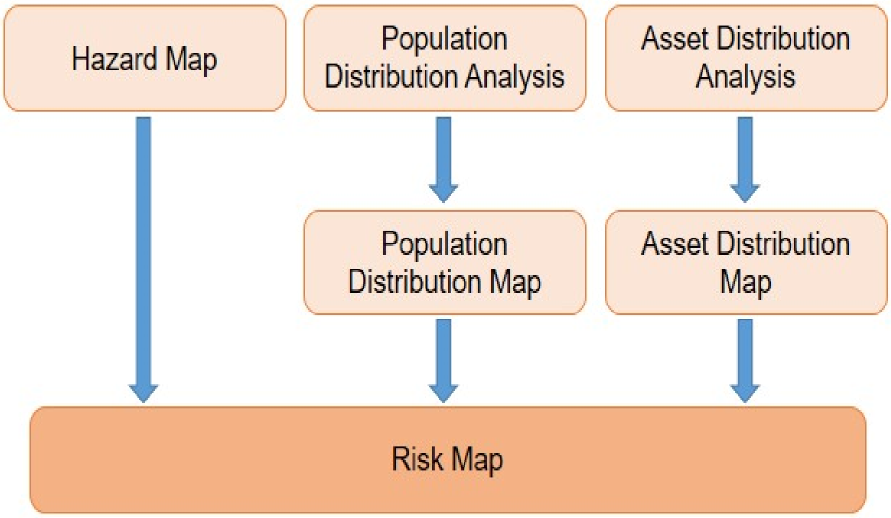


Source: JICA Expert and JICA Study Team

Figure 6-123 Flow of Disaster Risk Reduction Analysis with Mitigation Measures and Spatial Development Policy

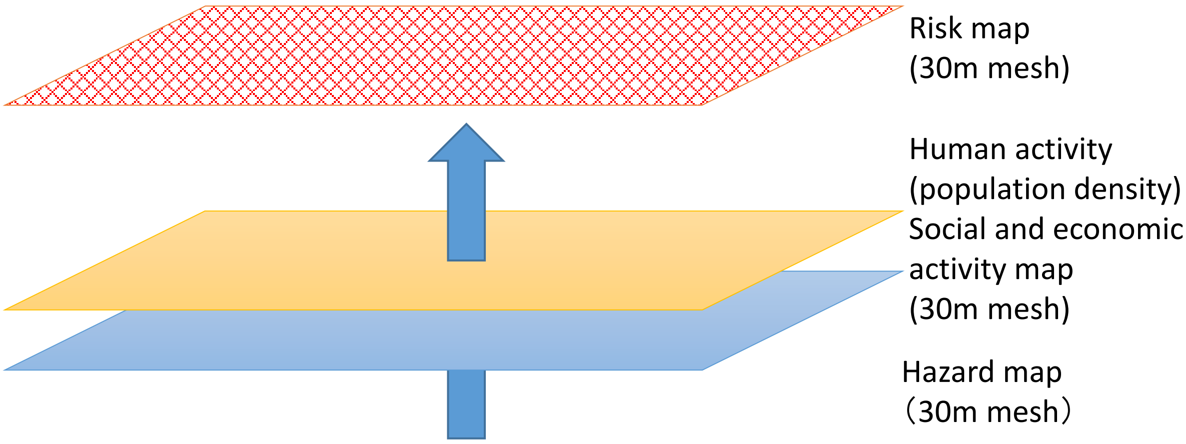
(2) Method of creating disaster risk map

In general, the disaster risk should be evaluated by composing of population and properties, preparedness, awareness and so on with hazard levels in the vulnerable areas. However, it is difficult to evaluate the other elements except for population and asset and put them into the calculation of risk. Therefore, hazard levels and population, properties are the three main elements of disaster risk evaluation. The flow and image of risk map creation is shown in Figure 6-124 and Figure 6-125. Hazard map should be prepared for understanding the type of hazard and hazard levels in 30m mesh. Population and asset distribution had been analysed to make its distribution map in 30m mesh scale. The risk map should be made up from hazard map, population and asset as shown in the flow. The risk map would be drawn on scale of 1:25000 as same as scale of hazard map with resolution of 30m mesh.



Source: JICA Expert and JICA Study Team

Figure 6-124 Flow of Risk Map Creation

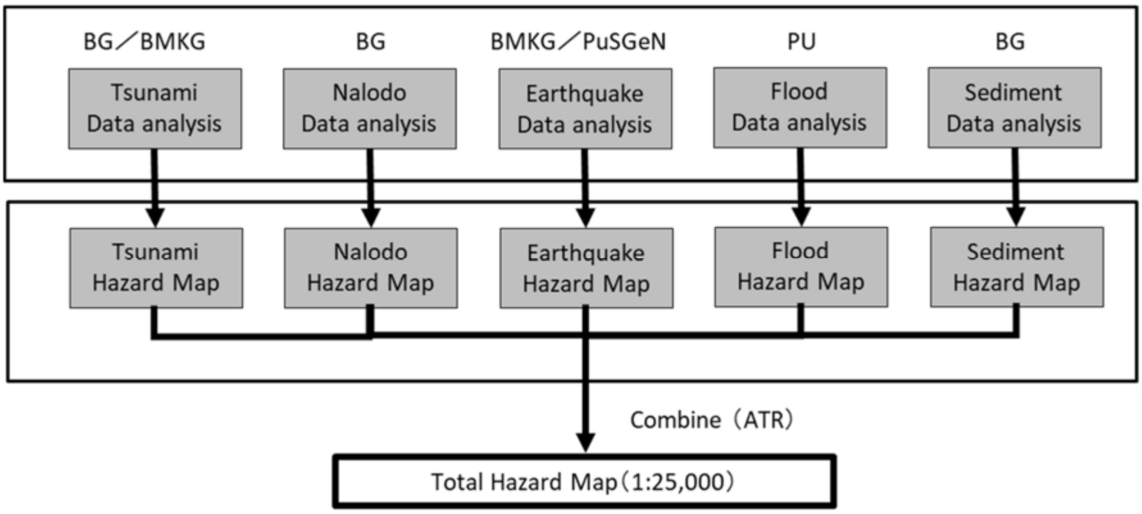


Source: JICA Expert and JICA Study Team

Figure 6-125 Image of Risk Map Creation in resolution of 30m mesh

(3) Hazard map preparation

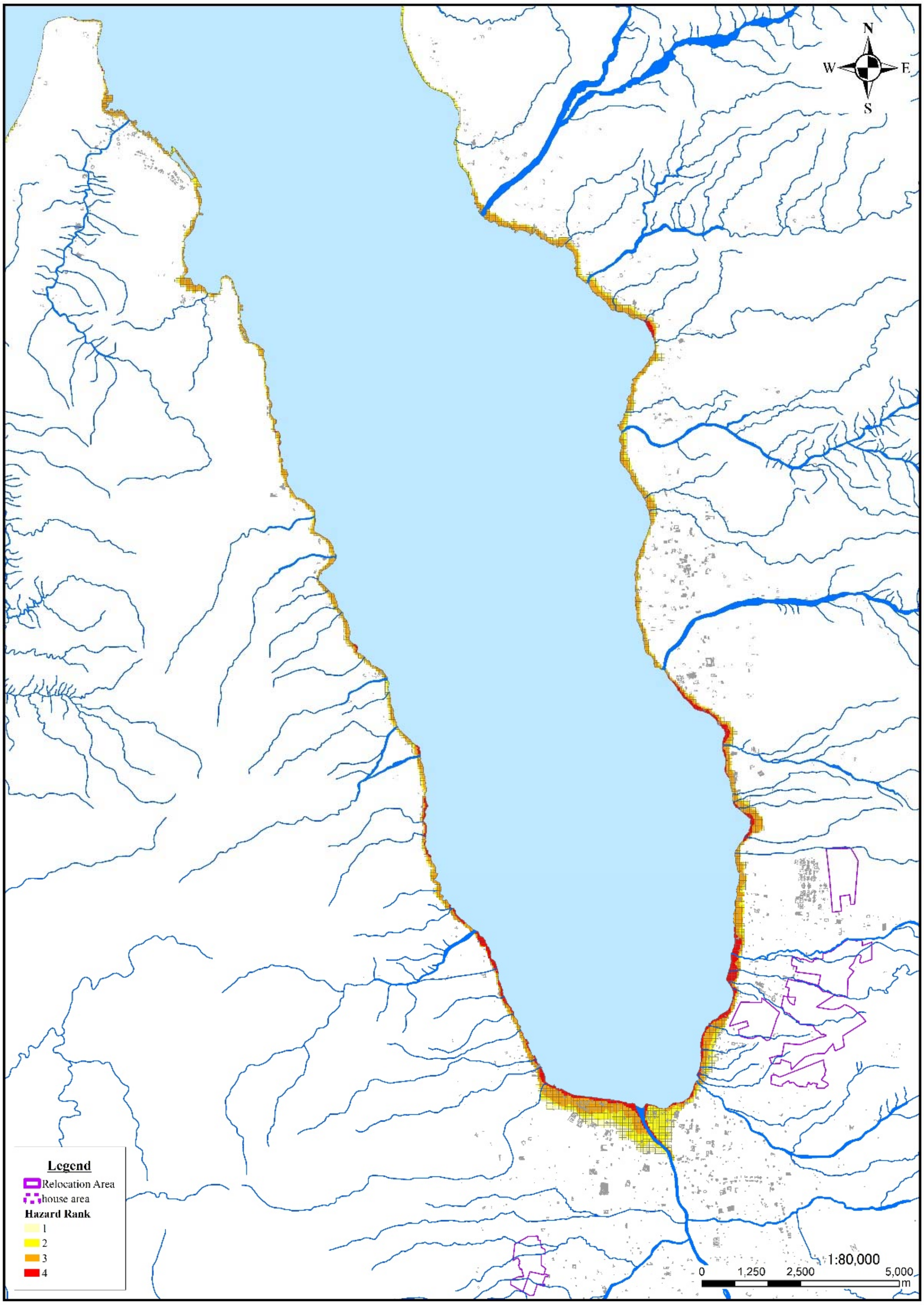
Hazard map has been created in activity I-4 as in below flow.



Source: JICA Experts, JICA Study Team

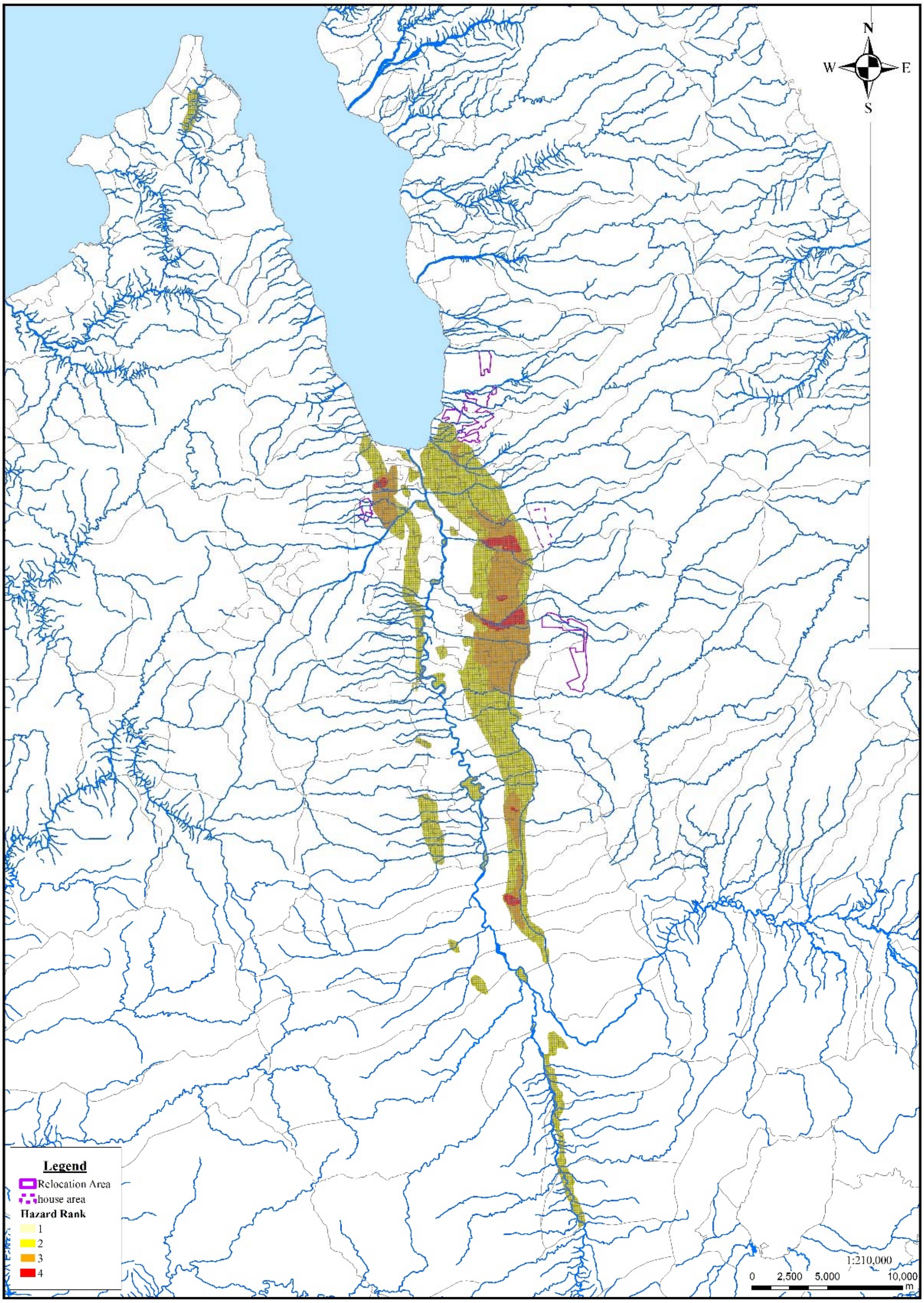
Figure 6-126　Flow of Hazard Map creation

In order to create risk map with resolution of 30m mesh, Hazard maps had been divided into 30m mesh for each hazard of tsunami, Nalodo, seismic, flood, sediment hazard map in 30m mesh shows in Figure 6-127 to Figure 6-131.



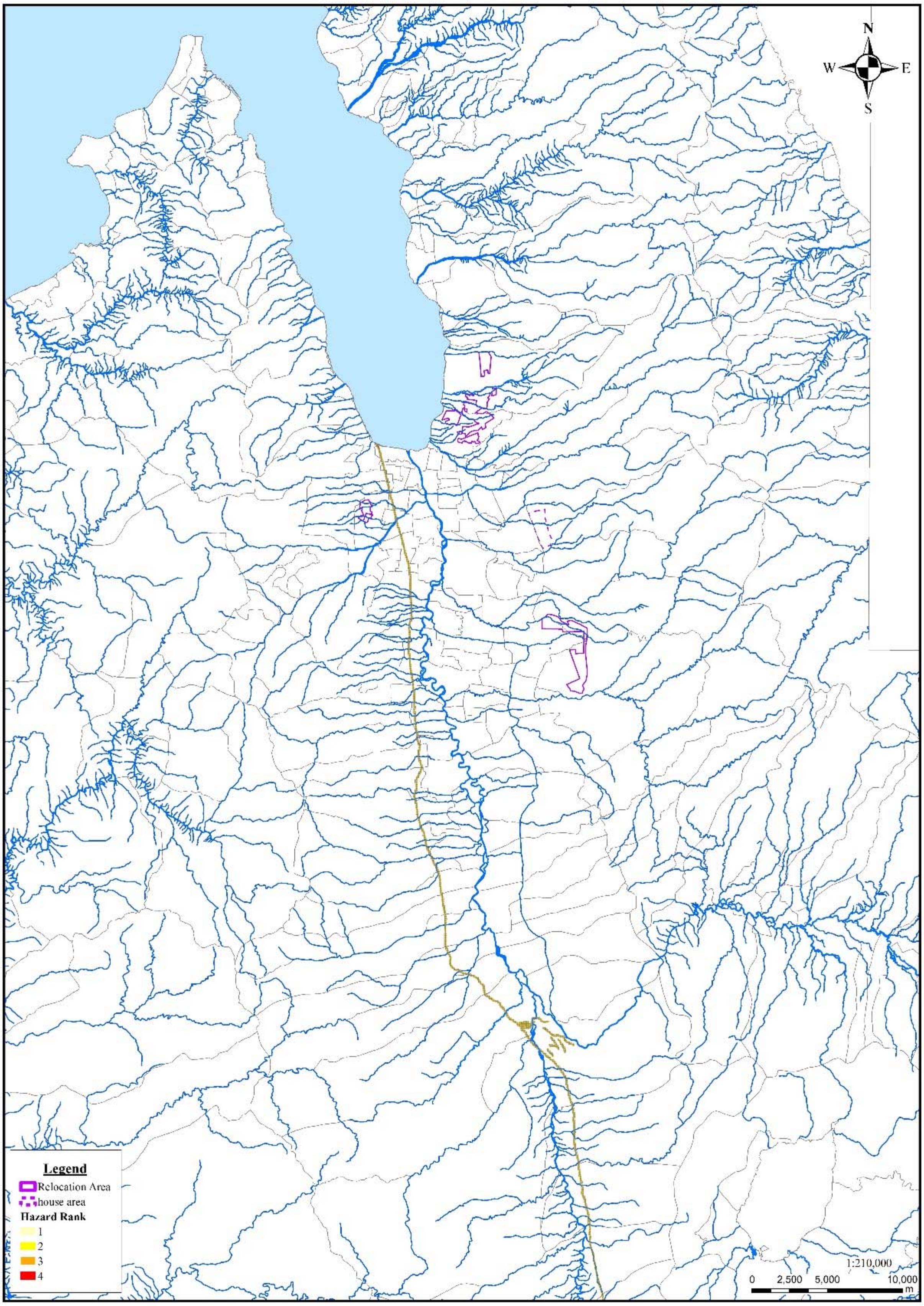
Source: JICA Expert and JICA Study Team

Figure 6-127 Tsunami hazard map (30m mesh)



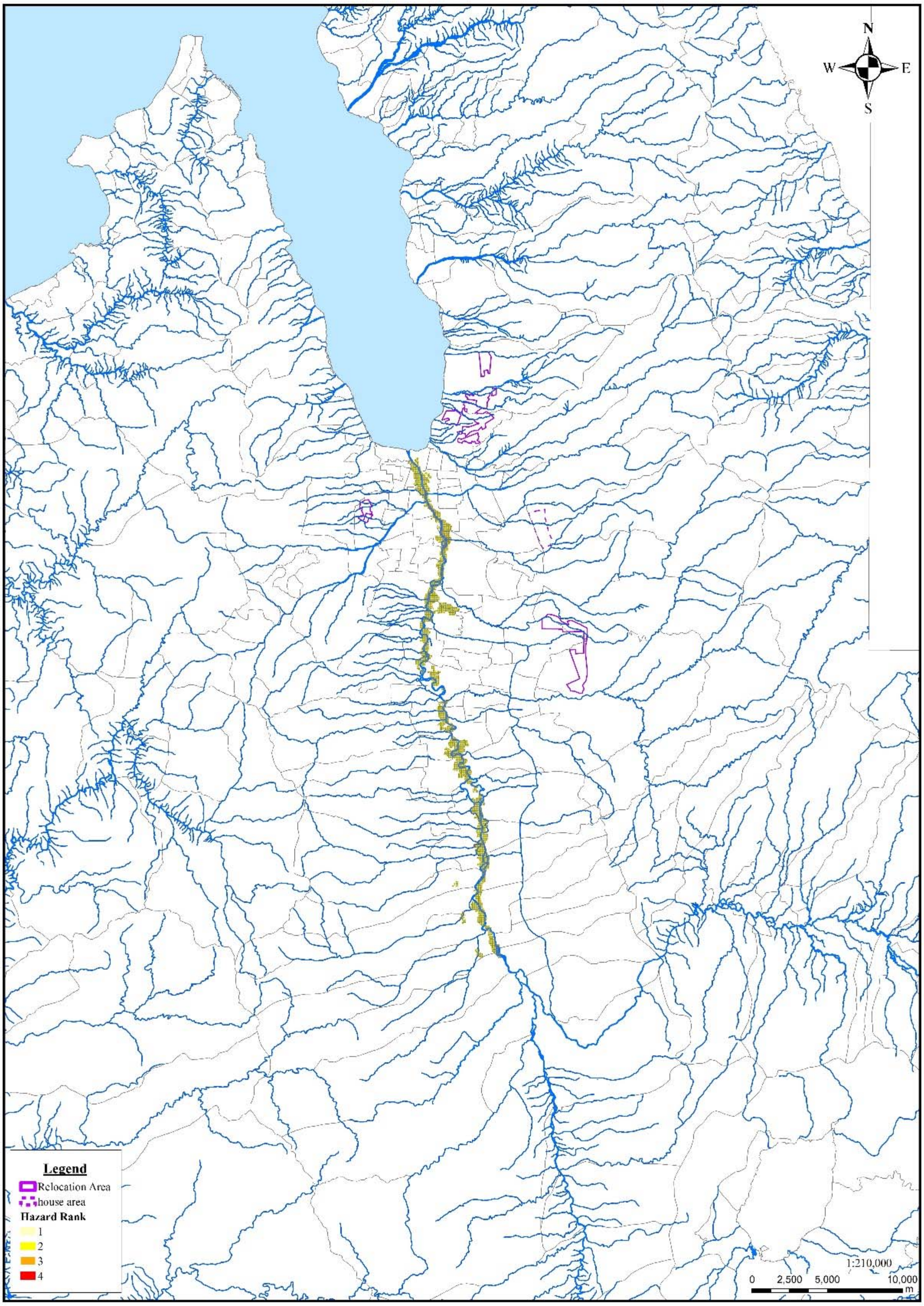
Source: JICA Expert and JICA Study Team

Figure 6-128 Nalodo hazard map (30m mesh)



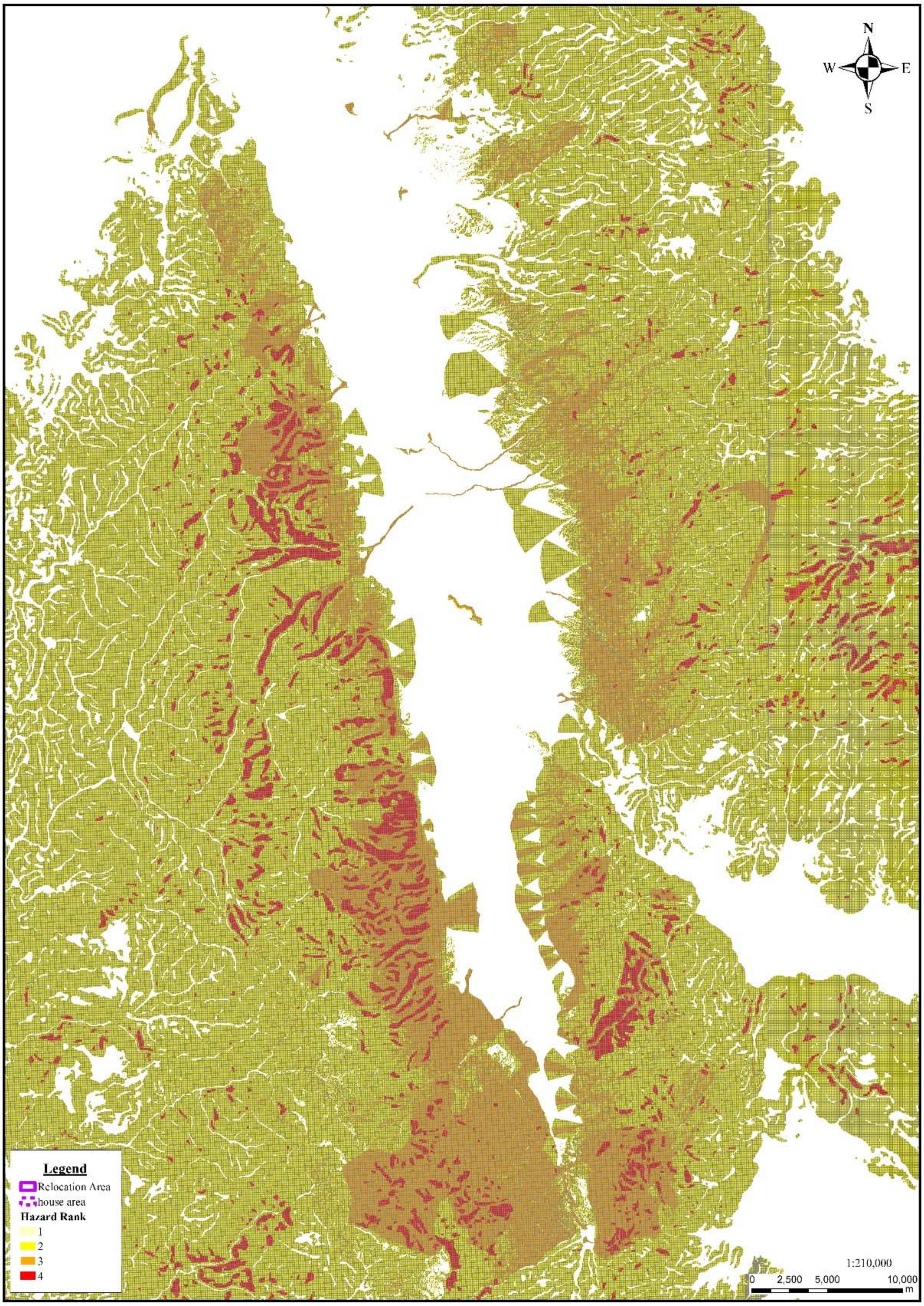
Source: JICA Expert and JICA Study Team

Figure 6-129 Seismic hazard map (30m mesh)



Source: JICA Expert and JICA Study Team

Figure 6-130 Flood hazard map (30m mesh)



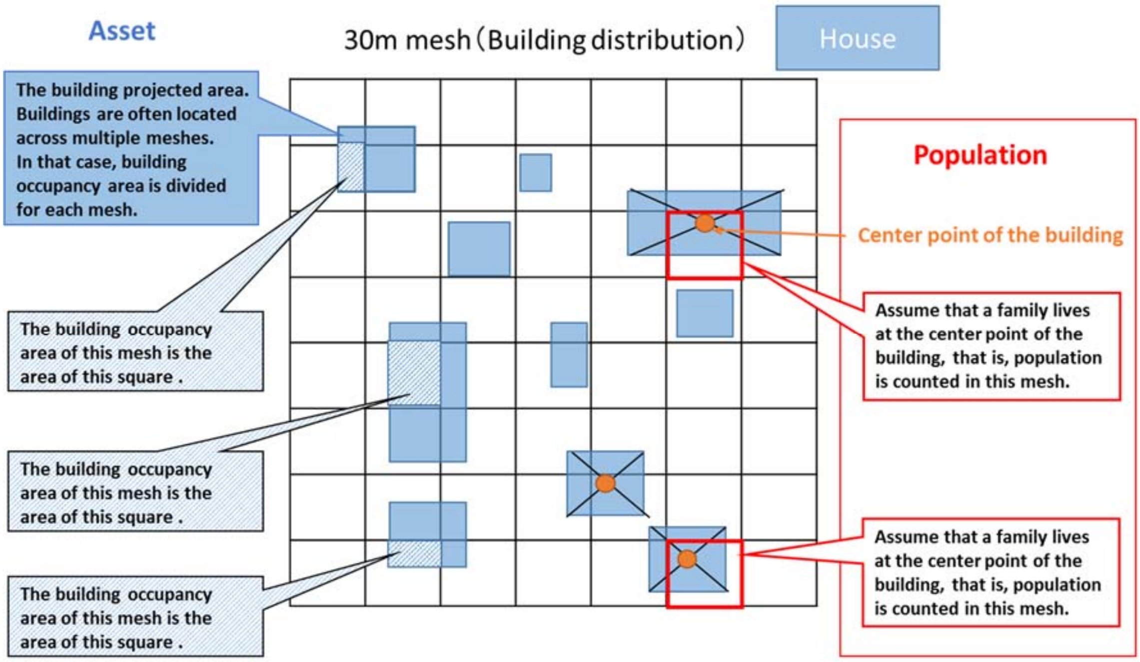
Source: JICA Expert and JICA Study Team

Figure 6-131 Sediment hazard map (30m mesh)

(4) Socio-economic & human activity map creation

Socio-economic and human activity has been evaluated through asset and population respectively. The population and asset distribution of commercial district, administrative district, public facilities are calculated in 30m mesh as same as hazard map. The population and asset are highly concentrated in Palu city and along coast. Calculation of population and asset are as below.

- Population distribution
  - First, identify the buildings of 1 or 2 floors (assume the buildings of 1 or 2 floor as a residential house)
  - Second, set center point of the identified building
  - Third, allocate the average number of families (around 4 people) to each 30 mesh that includes the center point in considering the population statistics of districts.



Source: JICA Expert and JICA Study Team

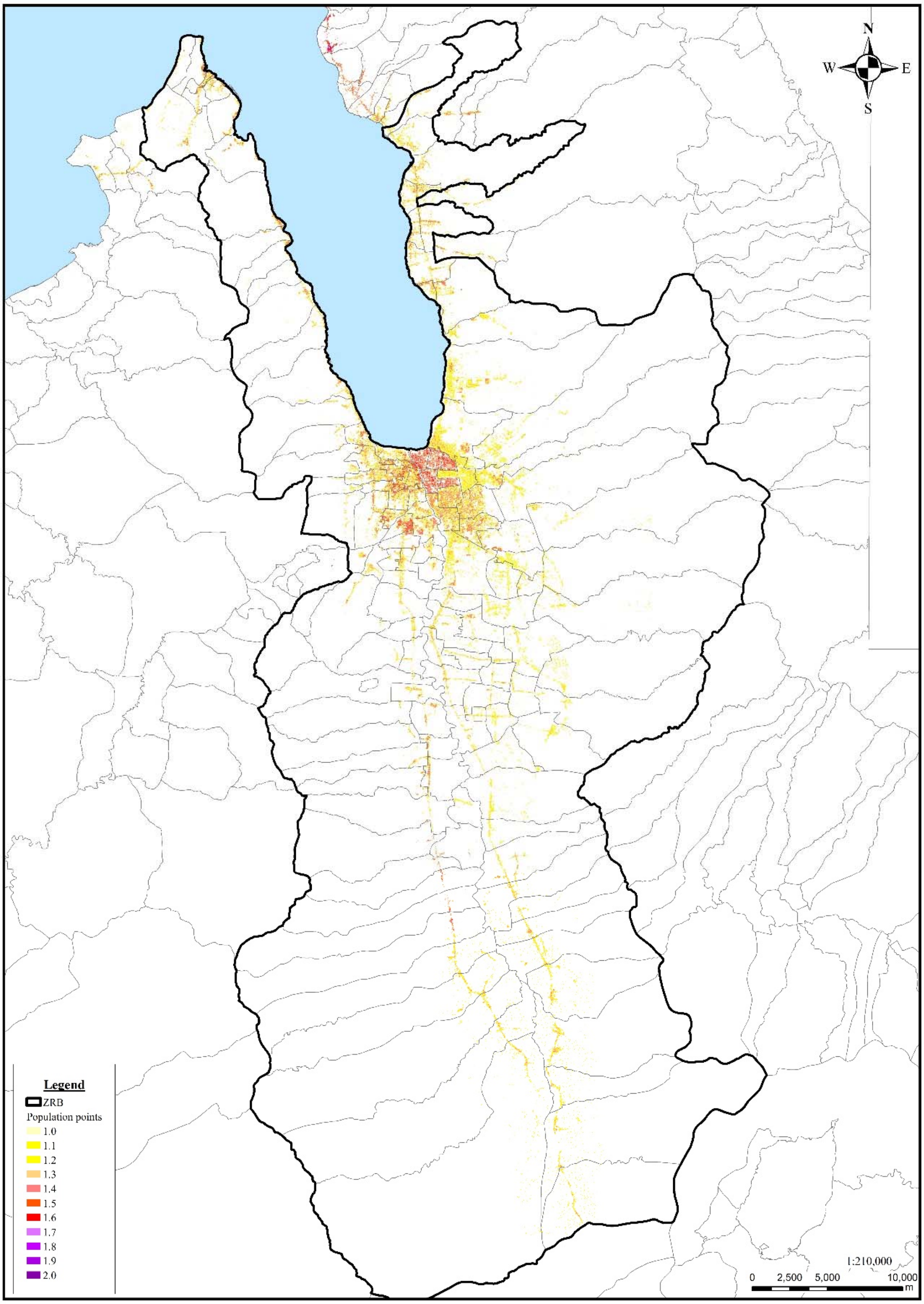
Figure 6-132 Image of population distribution calculation (30m mesh)

After calculation of population distribution in each mesh, the population will be referenced with hazard points as shown in Table 6-27. 0 point is considering as there is nobody lives, and there is no risk. If anyone lives, it is considering there is risk area and the risk will arise along with number of person from 1.0 to 2.0.

Table 6-27 Population hazard points

Population (person)	Score	Remark
0	0.0	If nobody lives, we judge that there is no risk
1	1.0	We think that risk will arise if anyone lives
1＜n≦2	1.1	
2＜n≦5	1.2	
5＜n≦10	1.3	
10＜n≦20	1.4	
20＜n≦30	1.5	
30＜n≦40	1.6	
40＜n≦50	1.7	
50＜n≦70	1.8	
70＜n≦100	1.9	
100＜n	2.0	Consider 2.0 points as the biggest point

Source: JICA Expert and JICA Study Team



Source: JICA Expert and JICA Study Team

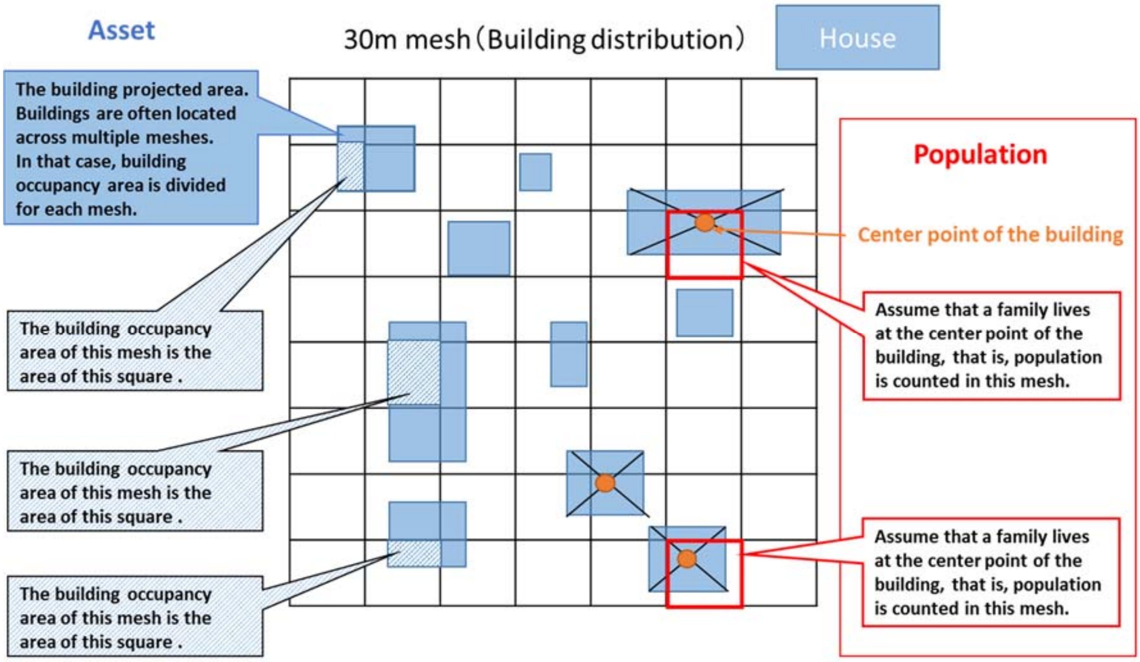
Figure 6-133 Population distribution map (30m mesh)

■ **Asset distribution**

➢ First, identify the shape of the building.

➢ Second, calculate the building occupancy area included in each mesh. For example, it is three times the projected area in case of 3 floors.

➢ Third, the property value is calculated by multiplying the calculated building occupancy area by the building unit price (3 million IDR / m 2).



Source: JICA Expert and JICA Study Team

Figure 6-134 Image of building distribution calculation (30m mesh)

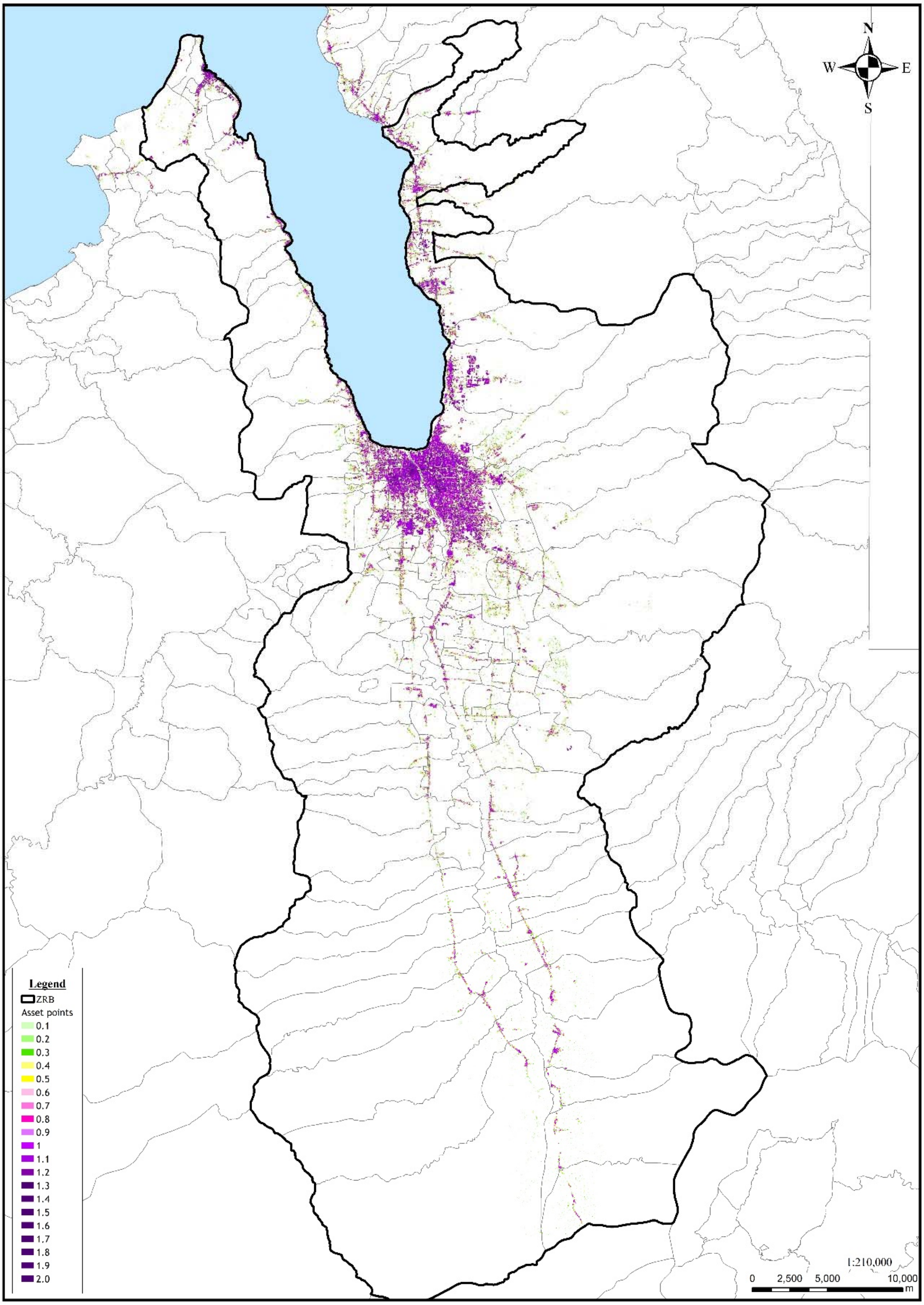
After calculation of asset distribution in each mesh, the asset value will be referenced with hazard points as shown in Table 6-28. The value of 1 square meter of building will be valued at 3 million IDR to calculate for all buildings in target area. The largest asset in the target area is 100,000 million IDR.

Table 6-28 Asset hazard points

Asset (million IDR)	Score	Remark
0	0.0	If there were no assets, We judged that there was no risk.
0 ＜n≦ 100	0.1	
100 ＜n≦ 200	0.2	
200 ＜n≦ 300	0.3	
300 ＜n≦ 400	0.4	
400 ＜n≦ 500	0.5	
500 ＜n≦ 600	0.6	

600 ＜n≦ 700	0.7	
700 ＜n≦ 800	0.8	
800 ＜n≦ 900	0.9	
900 ＜n≦ 1,000	1.0	
1,000 ＜n≦ 2,000	1.1	
2,000 ＜n≦ 5,000	1.2	
5,000 ＜n≦ 10,000	1.3	
10,000 ＜n≦ 20,000	1.4	
20,000 ＜n≦ 30,000	1.5	
30,000 ＜n≦ 40,000	1.6	
40,000 ＜n≦ 50,000	1.7	
50,000 ＜n≦ 70,000	1.8	
70,000 ＜n≦ 100,000	1.9	
100,000 ＜n	2.0	

Source: JICA Expert and JICA Study Team



Source: JICA Expert and JICA Study Team

Figure 6-135 Asset distribution map (30m mesh)

(5) Risk classification

The final risk level has been classified by multiplying the hazard level, the population point with asset point as shown in Table 6-29. In risk classification, it is considering that there is no risk in areas where people do not live or where there are no assets. Then, there will be more risk than the level of hazard, if anyone lives there. In other words, the more people live, the higher the risk level. The basic policy of calculation method of risk point is as follows.

■ **Population risk point**

If no one lives, risk point calculation formula is as below.

RLp = HL (4.0 ≥ HL points ≥ 1.0) x 0 = 0

RLp＝0.0

If many people live, the risk points are higher. Where people live, risk point calculation formula is as below.

RLp = HL (4.0 ≧ HL point ≧ 1.0) × (2.0 ≧ Population point ≧ 1.0)

8.0≧RLp≧1.0

Here, RLp is risk level of population; HL is hazard level.

■ **Asset risk point**

Asset risk point calculation formula is as below.

RLa = HL (4.0 ≧ HL point ≧ 1.0) × (2.0 ≧ Asset point ≧ 0.0)

8.0≧RLp≧0.0

Here, RLa is risk level of asset; HL is hazard level.

■ **Total risk point**

The total of risk point of population and asset is total risk level point and calculate as the following formula

RLt = RLp + RLa

Here, RLt is total risk level point.

Table 6-29 Calculation method of risk point

Hazard Score①	Population score②	Asset Score③	Risk point (①×②) ＋ (①×③)
4	0.0 ~ 2.0	0.0 ~ 2.0	0.0 ~ 16.0
3			0.0 ~ 12.0
2			0.0 ~ 8.0
1			0.0 ~ 4.0

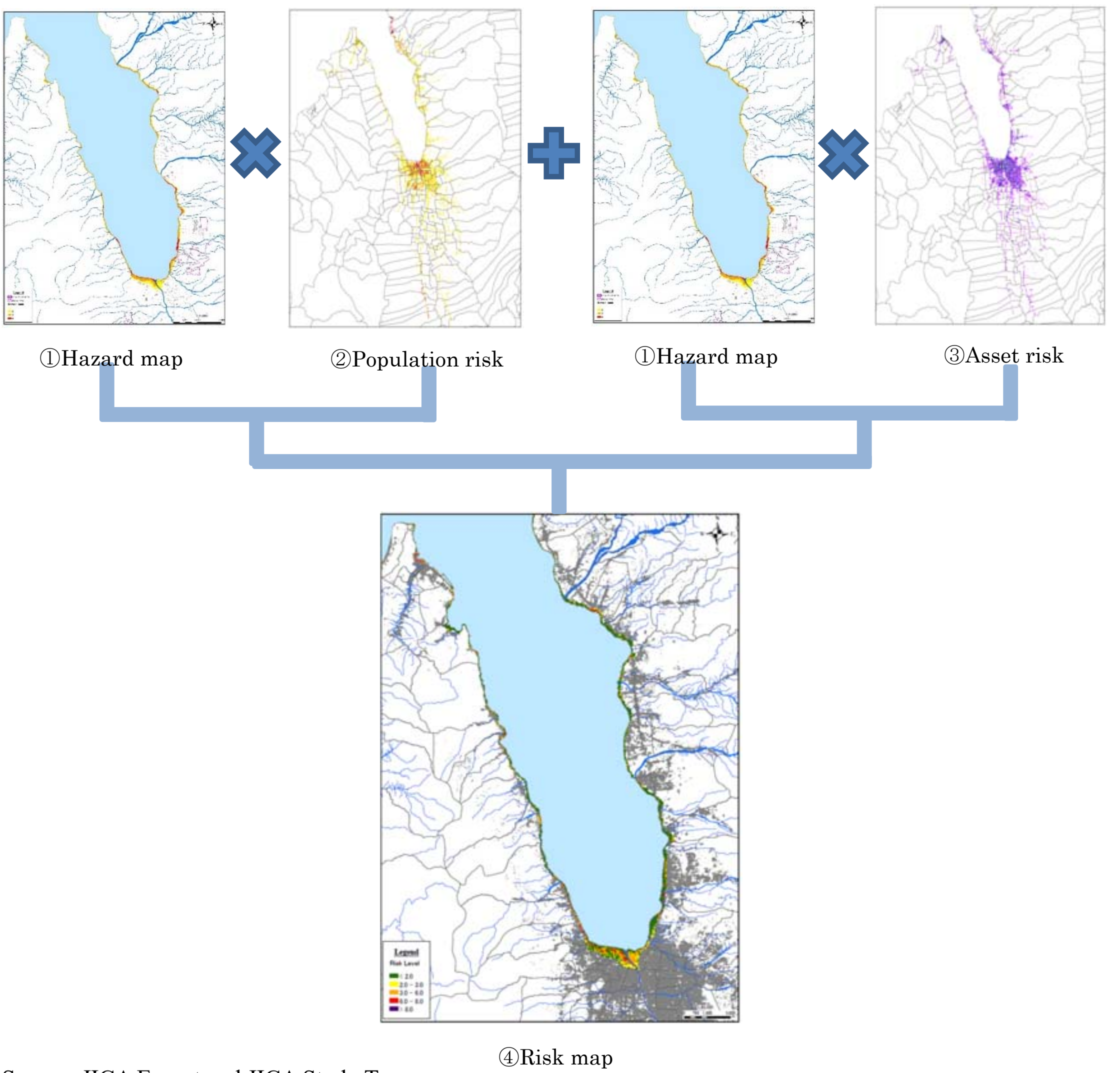
Source: JICA Expert and JICA Study Team

Based on the above risk point calculation method, risk level will be classified as below table.

Table 6-30　Risk level classification criteria

Risk point	BG hazard level	Description
Above 8	Extremely high	Extremely high risk area
6- 8	Very high	Very high risk area
3- 6	High	High risk area
2- 3	Medium	Medium risk area
Under 2.0	Low	Low risk area

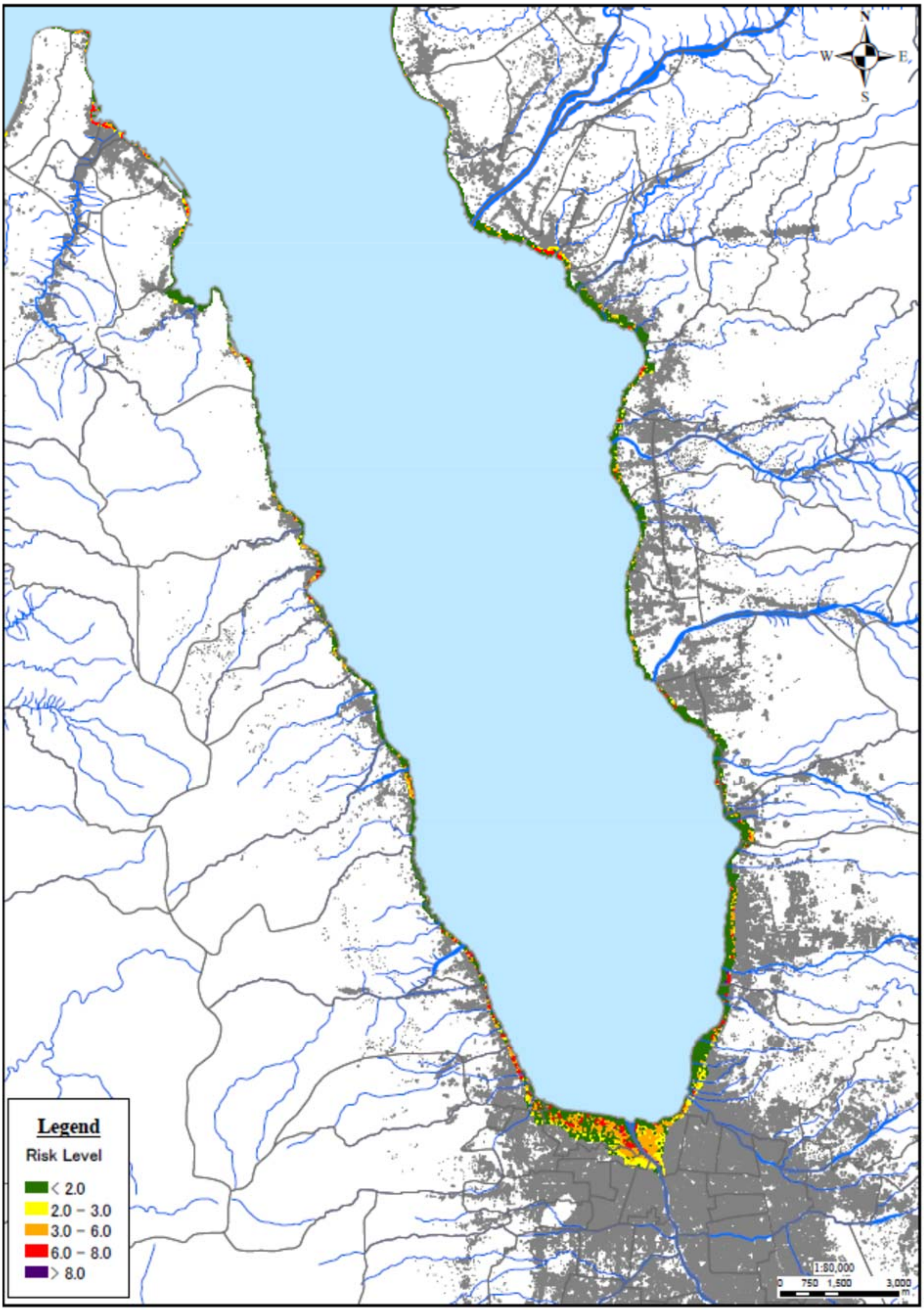
Source: JICA Expert and JICA Study Team



Source: JICA Expert and JICA Study Team

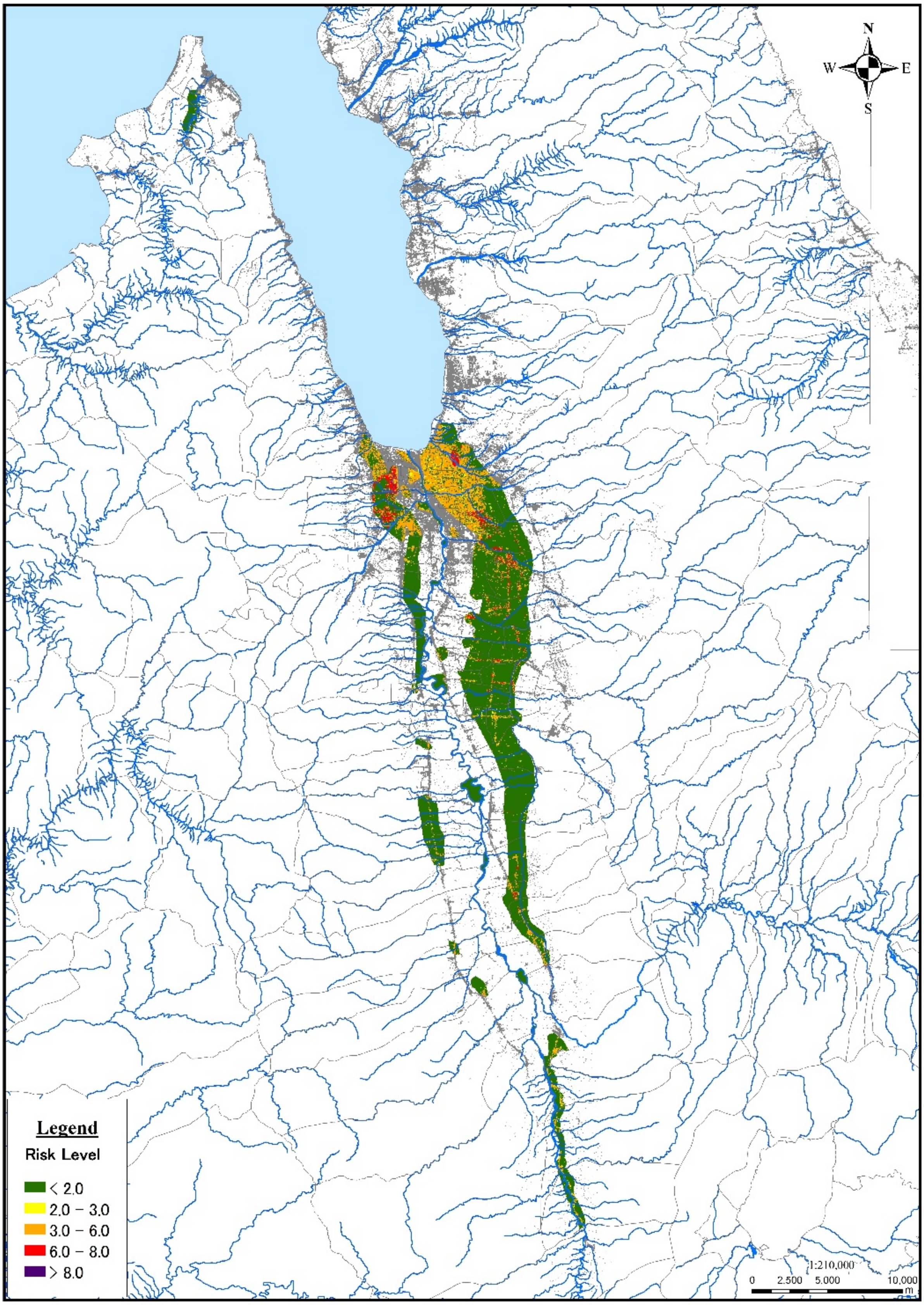
Figure 6-136　Image of Risk level calculation

Based on the above method, risk maps has been created for each disaster as shown below.



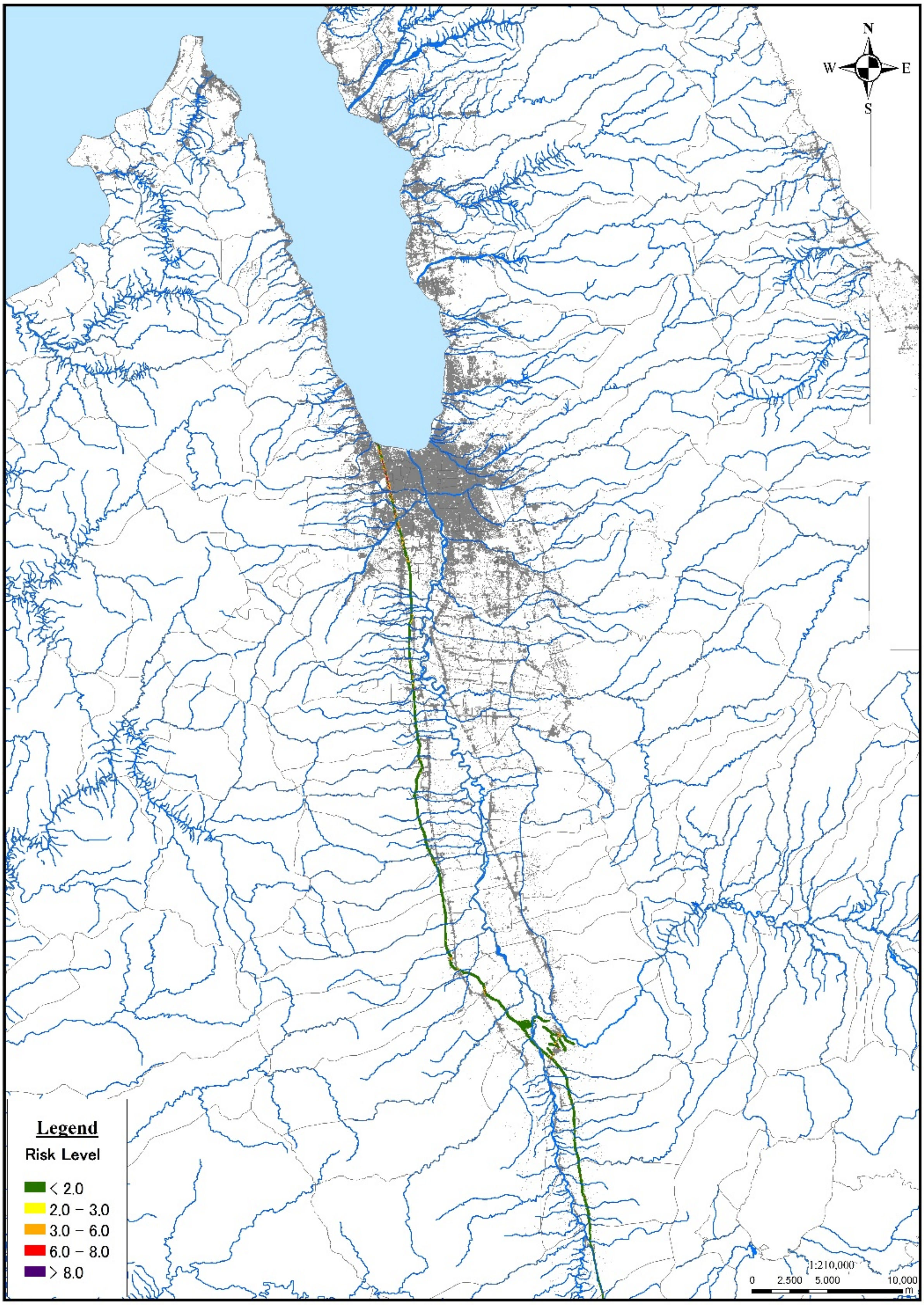
Source: JICA Expert and JICA Study Team

Figure 6-137 Tsunami risk map



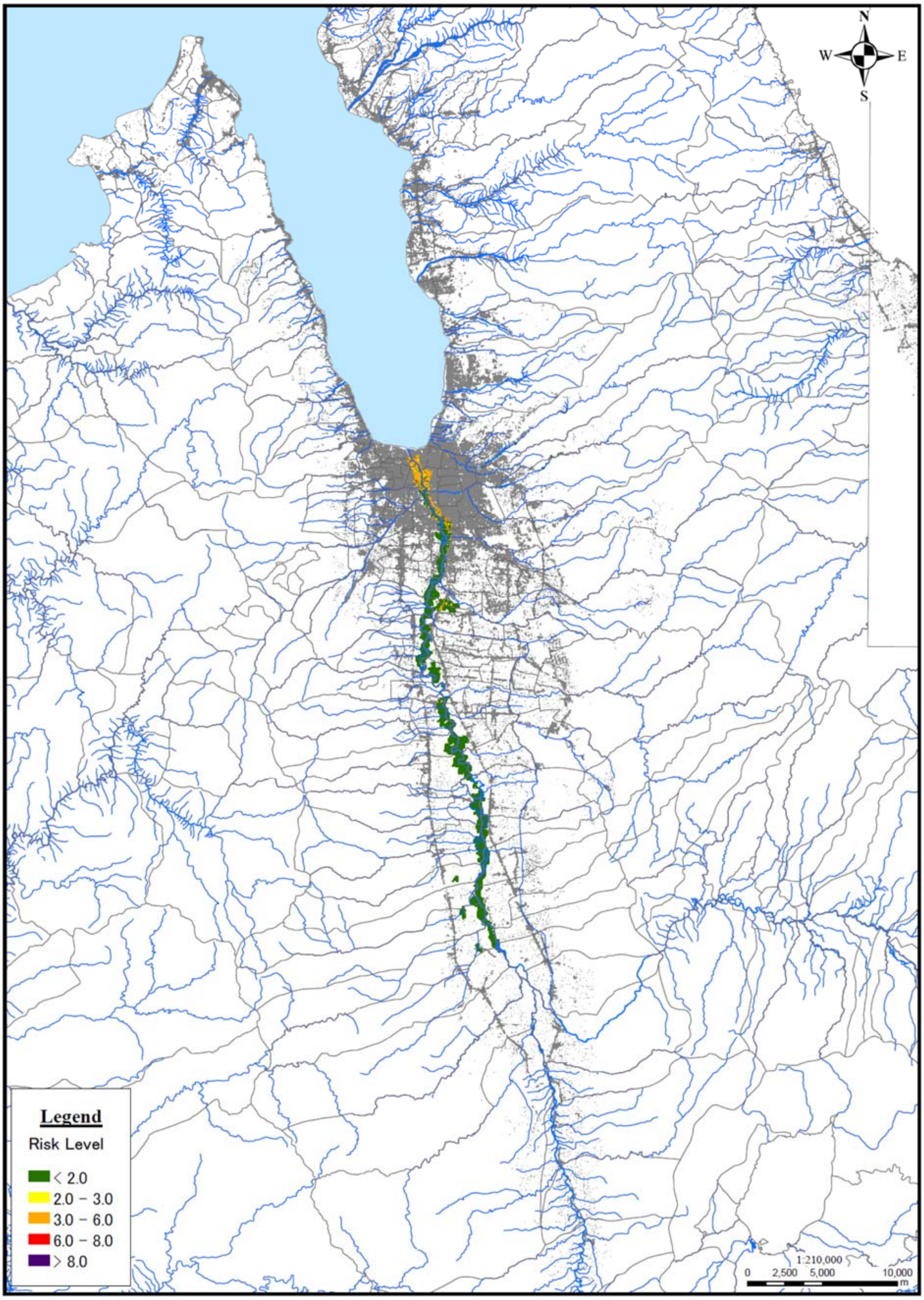
Source: JICA Expert and JICA Study Team

Figure 6-138 Nalodo risk map



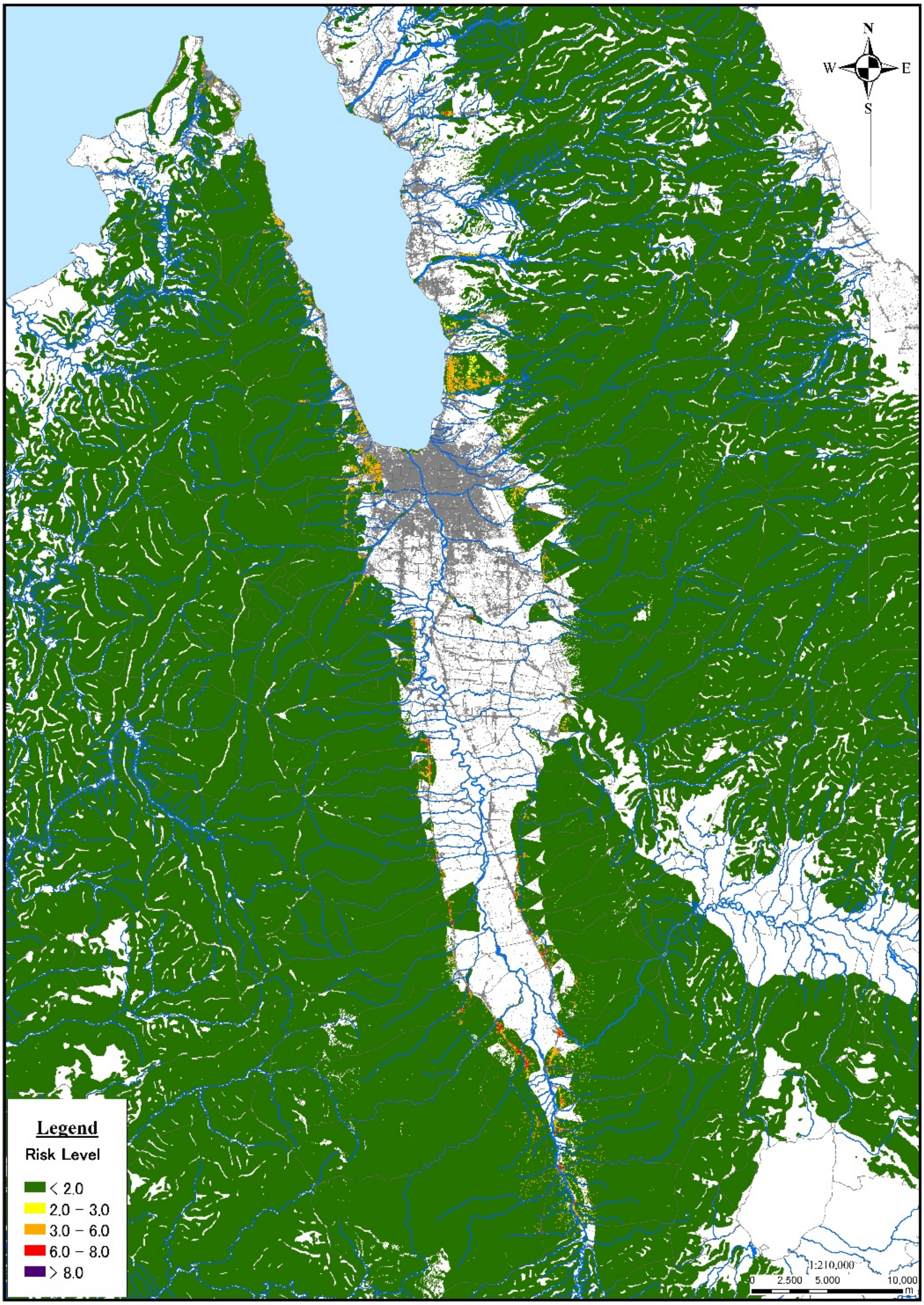
Source: JICA Expert and JICA Study Team

Figure 6-139 Earthquake risk map



Source: JICA Expert and JICA Study Team

Figure 6-140 Flood risk map



Source: JICA Expert and JICA Study Team

Figure 6-141 Sediment risk map

6-3-2 Preparation of Reference Manual

The risk map preparation method is formalized as the reference manual.

Reference manuals for five types of disaster (tsunami, Nalodo, earthquake, flood and sediment disaster) were prepared. The draft reference manuals was attached in this report (refer to Appendix). In this section, the list of contents are shown in the table below.

Table 6-31 Contents of Draft Reference Manuals (Output 1)

PART II Draft Reference Manuals for Formulating Disaster Risk Maps (Output①)

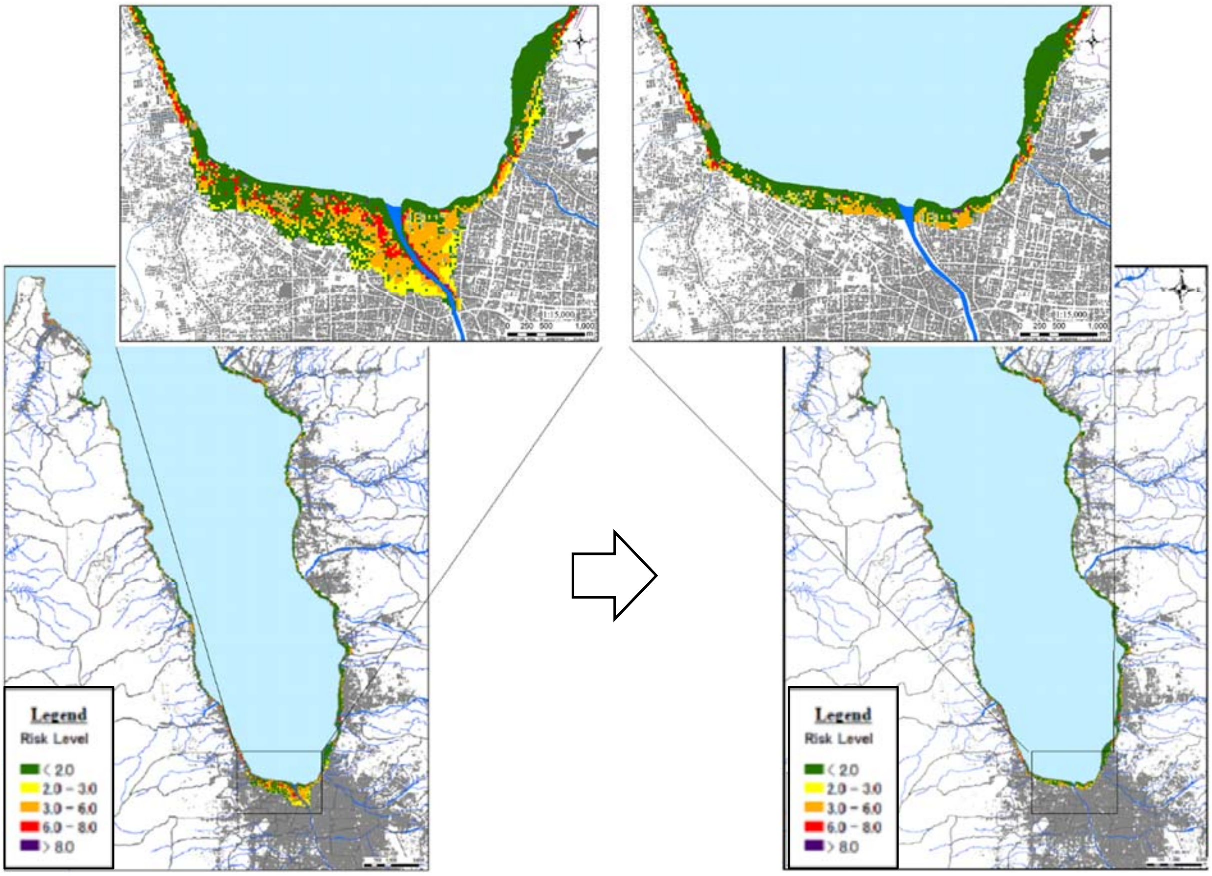
Source: JICA Expert and JICA Study Team

6-3-3 Risk Maps after Countermeasures

The risk maps for tsunami, Nalodo, flood, and sediment disasters have been prepared based on the current condition and the condition with countermeasures implemented/installed. The risk map before countermeasure implementation/installation indicates the current risk of the target areas by showing magnitude of risks. Whereas the risk map after countermeasure implemented/installed illustrates how much reduction is achieved on the magnitude of risks of the areas with countermeasure effects (risk reduction effect).

(1) Tsunami Risk Map (before and after countermeasures)

The risk map after countermeasure implementation/installation (Figure 6-142) is utilized to evaluate the economic and population damages.

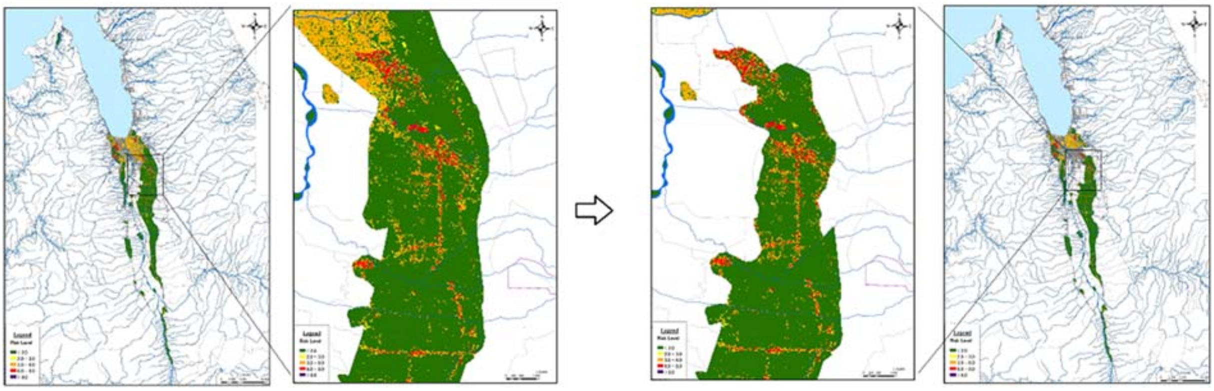


Source: JICA Experts and JICA Study Team

Figure 6-142 Tsunami Risk Maps before and after Countermeasures
(Left: before countermeasures, Right: after countermeasures)

(2) Nalodo Risk Map (before and after countermeasures)

The risk map after countermeasure implementation/installation (Figure 6-143) is utilized to evaluate the economic and population damages.

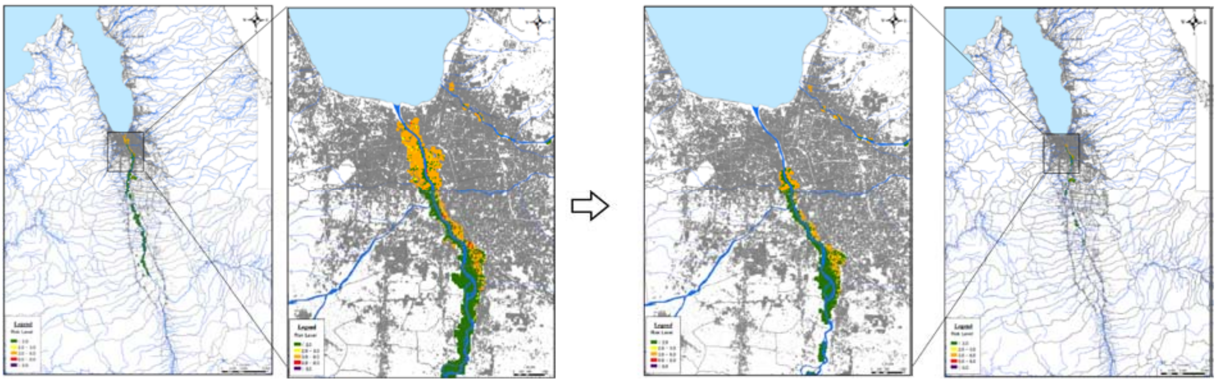


Source: JICA Experts and JICA Study Team

Figure 6-143 Nalodo Risk Map before and after Countermeasures
(Left: before countermeasures, Right: after countermeasures)

(3) Flood Risk Map (before and after countermeasures)

The risk map after countermeasure implementation/installation (Figure 6-144) is utilized to evaluate the economic and population damages.

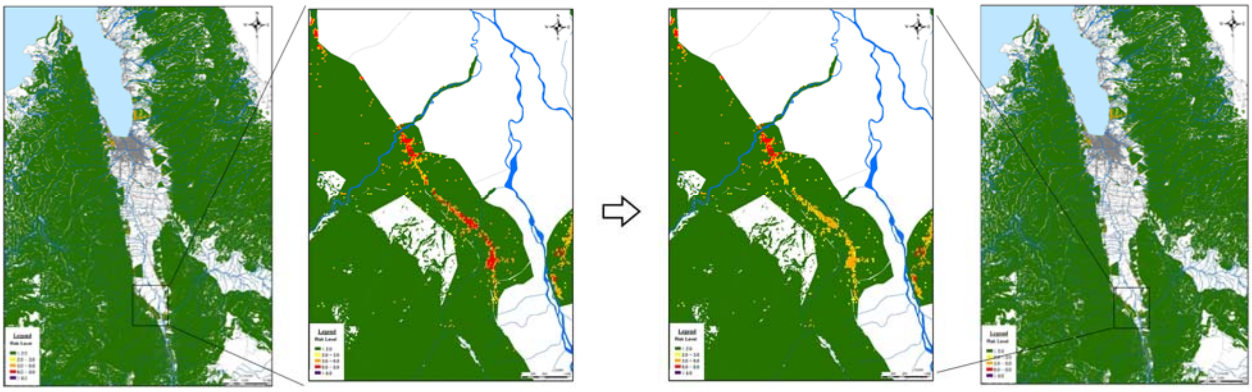


Source: JICA Experts and JICA Study Team

Figure 6-144 Flood Risk Map before and after Countermeasures
(Left: before countermeasures, Right: after countermeasures)

(4) Sediment Risk Map (before and after countermeasures)

The risk map after countermeasure implementation/installation (Figure 6-145) is utilized to evaluate the economic and population damages.



Source: JICA Experts and JICA Study Team

Figure 6-145 Sediment Risk Map before and after Countermeasures
(Left: before countermeasures, Right: after countermeasures)

Chapter 7 Lessons and Recommendations

(1) Establishment of proper management methods and systems for Gumbasa irrigation canals

The reconstruction of irrigation Gumbasa canals is an essential project to promote agricultural recovery in Petobo and Jono Oge districts where Nalodo occurred. Since this recovery M/P and feasibility study (hereinafter referred to as "F/S") was implemented with the support of another donor, the Asian Development Bank (hereinafter referred to as "ADB"), based on the concept of BBB, the project advised that the implementation of groundwater monitoring, establishment of irrigation canal management system, and development of detailed irrigation canal management plan are important for disaster risk reduction.

In the implementation stage of the irrigation canal recovery project, it is expected that the relevant organizations will discuss the establishment of appropriate management methods and systems based on the above advice under the leadership of the PUPR.

(2) Regularly update hazard maps based on infrastructure recovery status and groundwater monitoring results

Since the draft hazard map is planned to be used as the basic material for studying the spatial planning plan and the recovery plan for infrastructure and public facilities, the work in a limited time was a big challenge. In this connection, it can be said that it is a great achievement that the knowledge of academics from both countries was collaborated, the refinement work was carried out based on the analysis of the survey results, and the draft hazard map has been created. However, it was learned that it is necessary to update the continuous monitoring information of groundwater, the contents of RDTR, and the restoration status of infrastructure for further refinement.

The spatial plan for the area is scheduled to be updated every five years, and it is expected that this hazard map will be updated periodically by the relevant organizations under the leadership of Bappenas, based on the above updated information.

(3) Refinement of risk mitigation countermeasures based on the RDTR

The project supported the formulation of the RDTR proposal, which incorporates risk reduction measures for various disasters (tsunami, Nalodo, earthquake, flood, and landslide) in addition to land use regulations that take disaster mitigation measures into consideration.

When the RDTR formulated by the local government is finally approved, it is expected that the PUPR will review the risk reduction measures based on the land use regulations, etc. and reflect them in the project implementation stage.

National Development Planning Agency (BAPPENAS)

Project for Development of Regional Disaster Risk Resilience Plan in Central Sulawesi in the Republic of Indonesia

FINAL REPORT
(Volume III)

November 2021

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

JICA Expert, Comprehensive Disaster Risk Reduction, BNPB
JICA Expert, Integrated Water Resources Management, PUPR

Yachiyo Engineering Co., Ltd.
Oriental Consultants Global Co., Ltd.
Nippon Koei Co., Ltd.
Pacific Consultants Co., Ltd.
PASCO CORPORATION

IM
JR
21-053

Preface

In response to a request from the Government of Indonesia, the Japan International Cooperation Agency (hereinafter referred to as “JICA”) assisted on understanding the disaster situation and formulated a Reconstruction Master Plan. The assistance started by dispatching the first survey team to collect information on the disaster situation and emergency assistance in October 2018. In addition, discussions on future seamless recovery and reconstruction assistance measures were held with related Indonesian organizations, such as Bappenas. As a result, the Indonesian government requested JICA to implement a technical cooperation project for the recovery from the disaster, and it has been decided to implement this project (implementation period: December 2018 to November 2021): “Project for Development of Regional Disaster Risk Resili ence Plan in Central Sulawesi in the Republic of Indonesia” (hereinafter referred to as “the Project”). JICA entrusted the Project to Yachiyo Engineering Co., Ltd., Oriental Consultants Global Co., Ltd., Nippon Koei Co., Ltd., Pacific Consultants Co., Ltd., and PASCO CORPORATION.

Regarding the assistance for formulating the Reconstruction Master Plan, after the first survey team was dispatched immediately after the disaster in October 2018. Naoto TADA, JICA Expert of Comprehensive Disaster Risk Reduction, BNPB, and Jun HAYAKAWA, JICA Expert of Integrated Water Resources Management, PUPR (hereinafter referred to as "JICA Experts"), led the formulation of the Reconstruction Master Plan. To continue the seamless and reliable knowledge transfer from this Reconstruction Master Plan formulation assistance, JICA experts also provided guidance to the study team of the Project. The Project cited some charts created by the JICA experts during the Reconstruction Master Plan formulation.

This final report summarizes the results of JICA experts and the study team’s activities in the Project, and the findings from Japanese experts who participated in Japanese Support Committee.

In addition, using a part of the Project results as basic data, in June 2019, during the implementation period of the Project, a Grant Agreement (G/A) was signed for “The Programme for the Reconstruction of Palu 4 Bridges in Central Sulawesi Province”, which is the core infrastructure in the disaster area. Furthermore, in January 2020 an ODA Loan Agreement (L/A) was signed for the “Infrastructure Reconstruction Sector Loan in Central Sulawesi”, to promote infrastructures reconstruction such as roads, bridges, irrigation facility, rivers, and reconstruction of public facility (hospital).

Final Report Structure

The final report consists of a summary, main report and appendix. The detail results of the project are described in the main report. The main report consists of Volume I to Volume V.

<u>Summary (English)</u>

* Essential part from summary (Outline and Recommendation) is translated to Bahasa Indonesia and included in the report.

<u>Main Report (English)</u>

Volume I	Outline of the Project
Volume II	Disaster Hazard Assessment and Hazard Map
Volume III	Formulation of Spatial Plan Based on Disaster Hazard and Risk Assessment
Volume IV	Resilient Infrastructure and Public Facilities
Volume V	Livelihood Recovery and Community Restoration

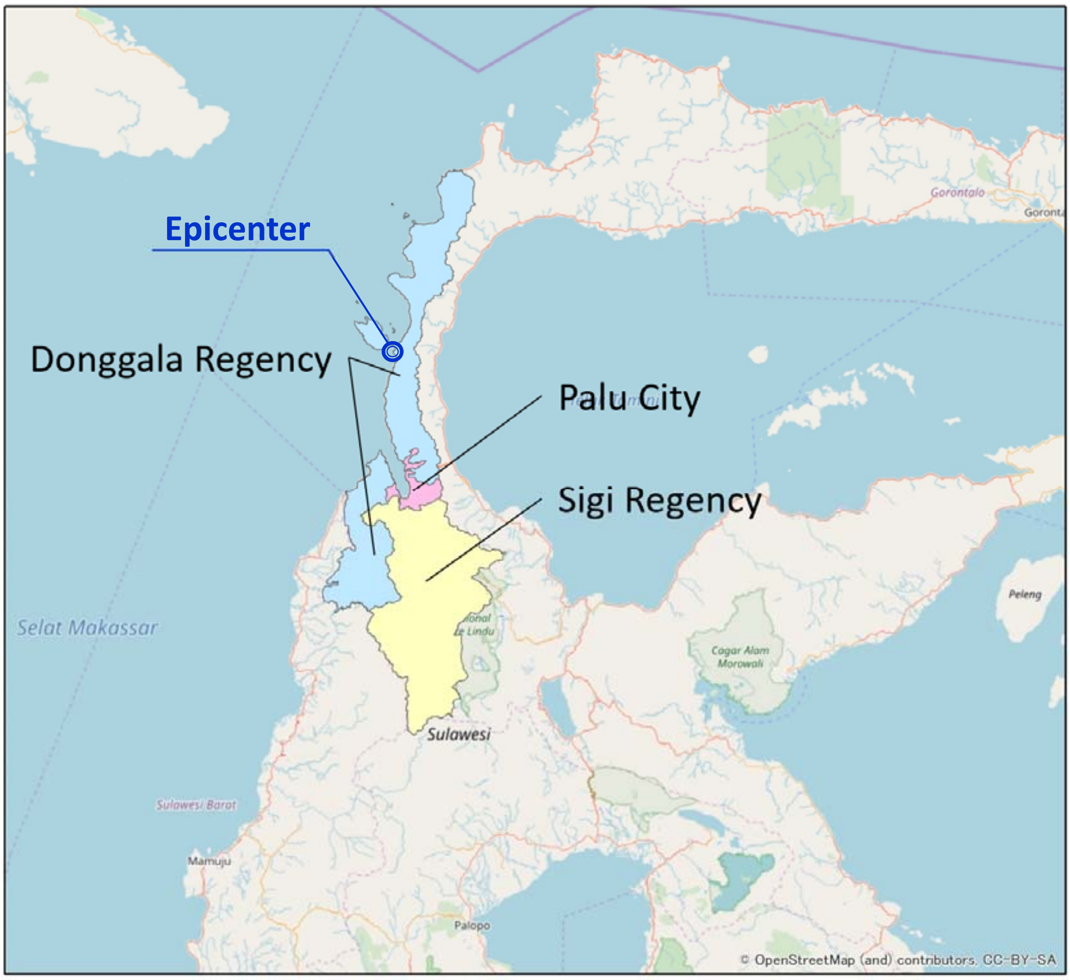
<u>Appendix</u>

US Dollar $ 1.00 = Indonesia Rupiah IDR 14,021.59 = Japanese yen ¥ 103.90
(February 2021)

Location Map of the Project Area

Location of Central Sulawesi Province

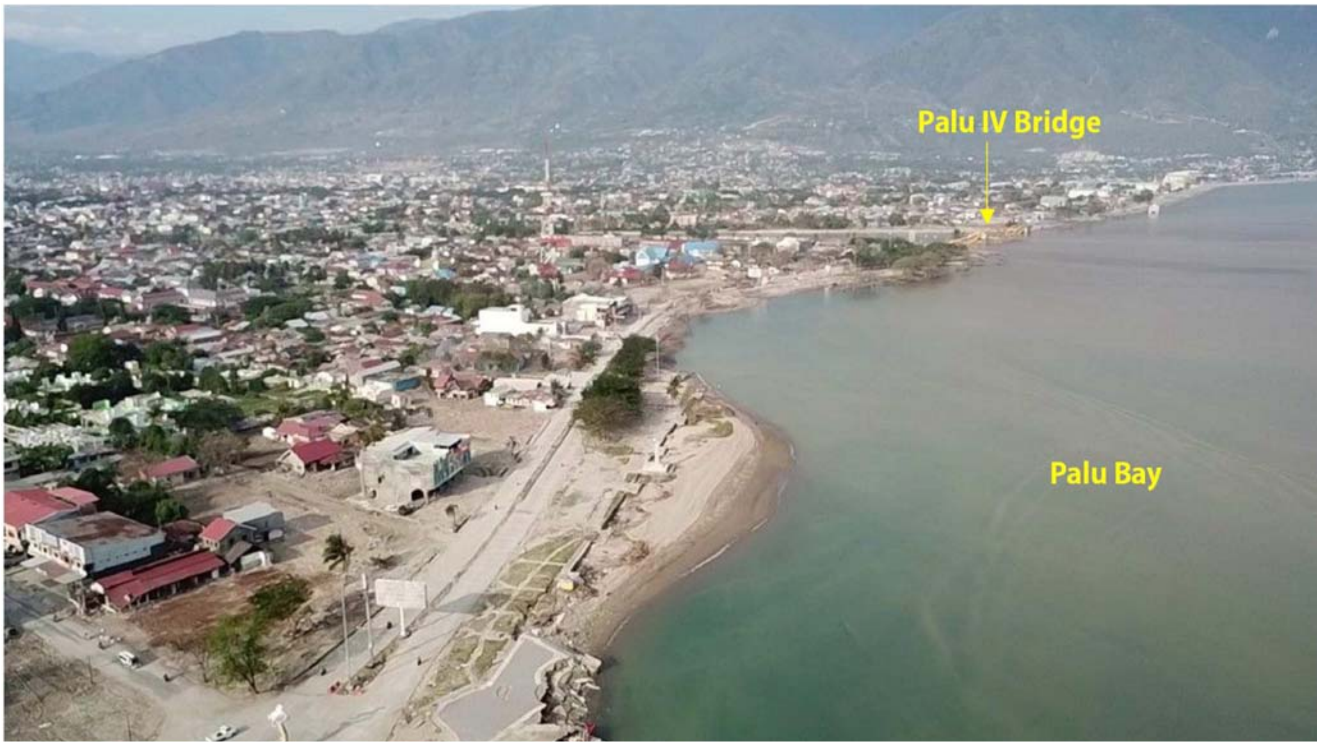
Location of Disaster Affected Area and Epicenter (Palu City, Sigi Regency and Donggala Regency)



Location of Target Area in the Project

Source: Prepared by JICA Study Team based on Data from the Geospatial Information Authority of Indonesia (BIG)

Damage Conditions



Condition of the Coastal Area of Palu Bay After the Disaster (Right Shore Side, Drone Shooting)

Condition of the Coastal Area of Palu Bay After the Disaster (Left Shore Side, Drone Shooting)

Lead-off Photos (2/7)

Damage Conditions

The Palu IV Bridge located at the Palu River Estuary was Collapsed by the Earthquake.

Collapsed Coastal Road along the Palu Bay

Damaged Buildings by Tsunami Inundation (100m to 450m from the Coast) (On the Right Shore of Palu Bay)

Damaged Port Facilities in the Palu Bay

(The Photo is SAMAS Container Jetty on the Left Shore of Palu Bay)

Damaged Road by Nalodo (Palu City)

Damaged in Sibalaya Area by Nalodo (Sigi Regency, Drone Shooting)

Lead-off Photos (3/7)

Damage Conditions

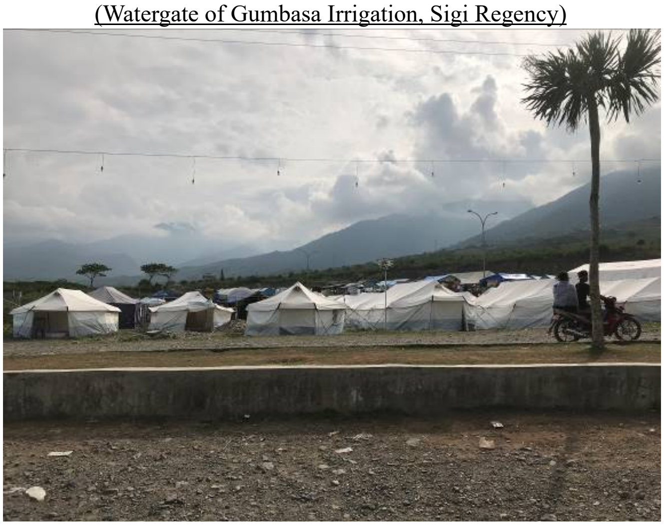
Damaged Caused by Floods and Landslides (Bangga River, Sigi Regency)

Sediment Disaster Caused by Debris Flow (Salua River, Sigi Regency)

Collapsed buildings by the Earthquake (Pal City)

Damaged Irrigation Facilities by Ground Deformation (Watergate of Gumbasa Irrigation, Sigi Regency)

Damaged in Sirenja Area by Inundation (Donggala Regency)



Evacuation Shelter Built in Balaroa District of Palu City After the Disaster

Lead-off Photos (4/7)

Stakeholder Discussions and Field Surveys

The First Joint Coordinating Committee (February 17, 2019)

Discussions with the Ministry of Land and Spatial Planning (ATR) and the National Land Agency (BPN)

(March 21, 2019)

Discussions on Infrastructure Reconstruction Plans with the Ministry of Public Works and National Housing (PUPR)
(February 18, 2019)

The Second Joint Coordinating Committee (August 6, 2019)

The Third Joint Coordinating Committee（December 11, 2019）

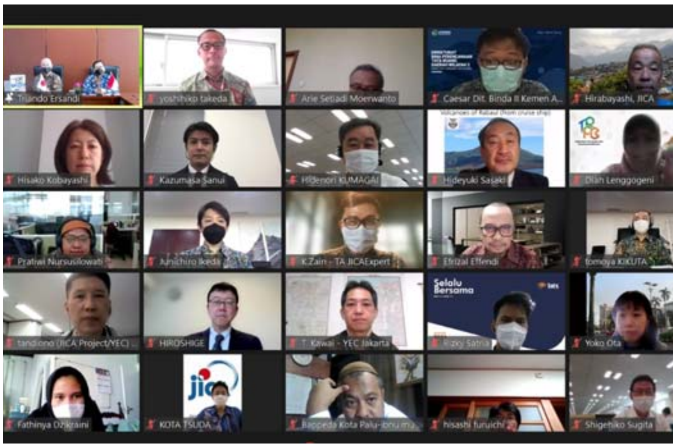
Discussion on the Japanese Support Committee (Nalodo)

(March 25, 2019)

Lead-off Photos (5/7)

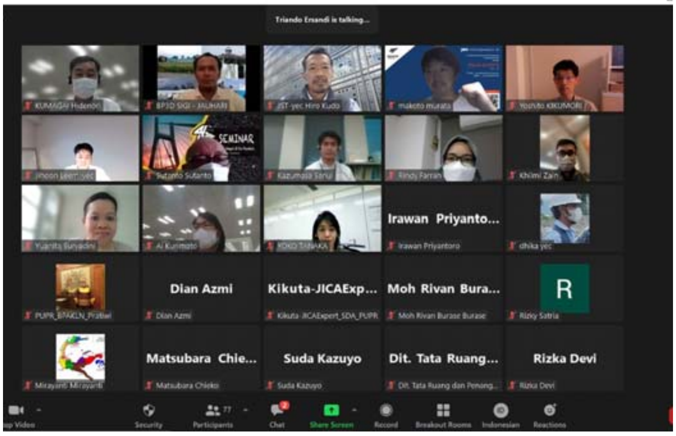
Stakeholder Discussions and Field Surveys

The Final Joint Coordinating Committee (October 6, 2021)
In Bappenas Meeting Room (Onsite participation)



The Final Joint Coordinating Committee (October 6, 2021)
By web communication tool (Online participation-1)

The Final Joint Coordinating Committee (October 6, 2021)
By web communication tool (Online participation-2)



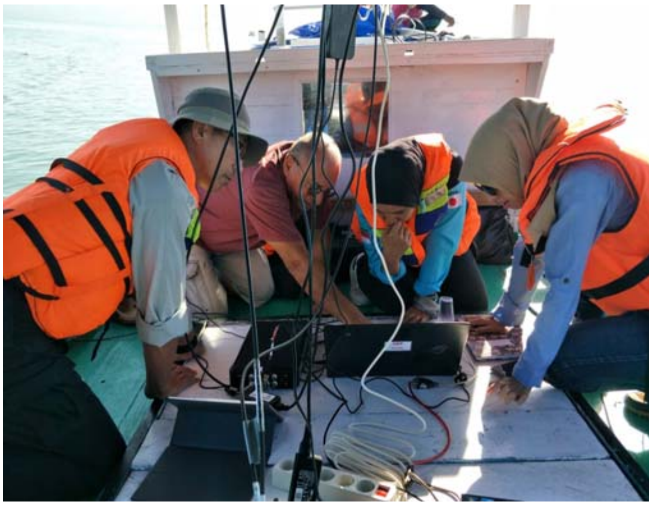
The Final Joint Coordinating Committee (October 6, 2021)
By web communication tool (Online participation-3)

Closing Ceremony – Handover report (October 6, 2021)

Closing Ceremony – Group picture (October 6, 2021)
(left-right); Mr. Ikeda; Mr. Kikuta; Mr. Fukushima; Mr. Tsuda, Mr. Sumedi, Ms. Lenggo

Lead-off Photos (6/7)

Stakeholder Discussions and Field Surveys



Reflection seismic survey of Palu Bay (Output 1 Activity)

A survey conducted to understand the geological composition and structure of the seabed at the southern of the Palu Bay, including the area around the Palu River Estuary (total 29.6 km).

Discussion with the Ministry of Land and Spatial Planning (ATR)
(Output 1 and Output 2 Activities, April 11, 2019)

Discussion with Local Government (Central Sulawesi)
(Output 2 Activity, March 18, 2019)

Discussion on Anutapura Hospital Design Review
(Output 3 Activity- Public Facilities Sector, April 9, 2019)

Palu IV Bridge Field Survey (Output 3-Road and Bridge Sector)

Survey for reconstruction of the collapsed Palu IV Bridge (January-May 2019).

Pilot Project Activities in Balaroa Shelter (Output 4 Activity)

Training was conducted twice to introduce Silar leaves weaving as an activity to obtain income in a short term.

Lead-off Photos (7/7)

Stakeholder Discussions and Field Surveys

Pilot Project Activities in Balaroa Shelter (Output 4)

Small culinary business activities were carried out by the groups of victims of the Balaroa evacuation shelter

Pilot Project Activities in M'panau Village (Output 4)

Training was conducted to improve the construction skills for the victims in the community in collaboration with vocational schools in the Province

Pilot Project Activities in M'panau Village (Output 4)

A MSMEs Centre was built to support the improvement of livelihood through micro business entities

Pilot Project Activities in Lero Tatari Village (Output 4)

20 fishing boats were provided to support the recovery of livelihood activities of a group of 40 fishermen.

Pilot Project Activities in Lero Tatari Village (Output 4)

Training on new processing technology of *Ikan Teri* (White bite) was conducted in cooperation with the department of SMEs in Central Sulawesi Province.

Pilot Project Activities in Lero Tatari Village (Output 4)

DRR education seminar was conducted for the pilot project beneficiaries by BPBD together with inviting BMKG and BASARNAS as lecturers

List of Abbreviation

Abbreviation	Indonesian Language	English
Organization / Institution		
AASHTO	—	American Association of State Highway and Transportation Officials
ACT	Aksi Cepat Tanggap	Quick Response Action
ADB	Bank Pembangunan Asia	Asian Development Bank
ADRA	—	Adventist Development and Relief Agency
AMC	—	Anutapura Hospital Medical Center
ASB	—	Arbiter Samariter Bund
ATR	Kementerian Agraria dan Tata Ruang	Ministry of Land and Spatial Planning
AusAID	—	Australian Agency for International Development
BAPPEDA	Badan Perencanaan Pembangunan Daerah	Regional Development Planning Agency
BAPPENAS	Badan Perencanaan Pembangunan Nasional	National Development Planning Agency
BG	Badan Geologi	Geological Agency
BIG	Badan Informasi Geospasial	Agency for Geospatial Information
BM	Bina Marga	Directorate General of Highways
BMKG	Badan Meteorologi, Klimatologi dan Geofisika	Agency for Meteorology, Climatology and Geophysics
BNPB	Badan Nasional Penanggulangan Bencana	National Disaster Management Authority
BPBD	Badan Penanggulangan Bencana Daerah	Regional Disaster Management Authority
BPN	Badan Pertanahan Nasional	Provincial land agency
BPPW	Balai Prasarana Permukiman Wilayah	Regional Settlement Infrastructure Center
BSN	Badan Standardisasi Nasional	National Standardization Agency
BWS	Balai Wilayah Sungai	River Basin Development Agency
Cipta Karya	—	Directorate General of Human settlements
CRS	—	Catholic Relief Services
CWS	—	Inanta Church World Service
DGST	Direktorat Jenderal Perhubungan Laut (DirJen Hubla)	Directorate General of Sea Transportation
Dinas	—	Agency
DKP	Dinas Kelautan dan Perikanan	Agency of Marine Affairs and Fisheries (at regional level)[1]
DLH	Dinas Lingkungan Hidup	Environmental Agency (at regional level)
DPMPTSP	Dinas Penanaman Modal dan Perijinan Terpadu Satu Pintu	One-stop office of integrated Investment and Permit Services
DPRP	Dinas Penataan Ruang dan Pertanahan	Local Spatial Planning and Land Service Agency
EA	—	Executing Agency
ESDM	Energi dan Sumber Daya Mineral	Ministry of Energy and Mineral Resources
FAO	Organisasi Pangan dan Pertanian Dunia	Food and Agriculture Organization
GOI	Pemerintah Negara Republik Indonesia	Government of Indonesia
HAKI	Himpunan Ahli Konstruksi Indonesia	Association of Indonesia construction expert
HATTI	Himpunan Ahli Teknik Tanah Indonesia	Indonesian Society For Geotechnical Engineering[2]

[1] Note: DKP at regional level (D = Dinas); KKP at national level (K=Kementerian/Ministry).

[2] Source: https://www.hatti.or.id/

Abbreviation	Indonesian Language	English
IFRC	—	International Federation of Red Cross and Red Crescent
ILO	Organizasi Pekerja Internasional	International Labour Organization
INGO	Lembaga Swadaya Masyarakat Internasional	International Non-Governmental Organization
INKINDO	Ikatan Nasional Konsultan Indonesia	National association of Indonesian Consultant
JCC	Komite Koordinasi	Joint Coordinating Committee
JFPR	—	Japan Fund for Poverty Reduction
JICA	—	Japan International Cooperation Agency
JST	Tim Studi JICA	JICA Study Team
KfW	Lembaga Pendanaan untuk Rekonstruksi - Jerman (Kreditanstalt für Wiederaufbau)	A German State-owned Development Bank
KKP	Kementerian Kelautan dan Perikanan	Ministry of Maritime Affairs and Fisheries
KPKPST	Kelompok Perjuangan Kesetaraan Perempuan Sulawesi Tengah	Central Sulawesi Women's Equality Group
LNGO	Lembaga Swadaya Masyarakat Lokal	Local Non-Governmental Organization
LTF	Satuan Tugas Lokal	Local Task Force
MCI	—	Mercy Corps Indonesia
MDMC	Pusat Manajemen Bencana Muhammadiyah	Muhammadiyah Disaster Management Center
Ministry of Cooperatives and SMEs	Kementerian Koperasi dan Usaha Kecil dan Menengah, Republik Indonesia	Ministry of Cooperatives and Small and Medium Enterprises
MOT	Kementerian Perhubungan	Ministry of Transport
NGO	Lembaga Swadaya Masyarakat (LSM)	Non-Governmental Organization
OGD	Departemen Kebidanan dan Kandungan[3]	Obstetrics and Gynecology Department
PARCIC	—	PARC Interpeoples' Cooperation
PMI	Palang Merah Indonesia	Indonesian Red Cross Societies
PUPR	Kementerian Pekerjaan Umum dan Perumahan Rakyat	Ministry of Public Works and Public Housing
PuSGen	Pusat Studi Gempa National	National Center for Earthquake Studies
PUSKIM	Pusat Kebudayaan Indonesia	Indonesian Cultural Center
SATGAS	Satuan Tugas	Task Force
SDA	Direktorat Jenderal Sumber Daya Air	Directorate General of Water Resources
SKP-HAM	Solidaritas Korban Pelanggaran Hak Asasi Manusia	Solidarity of Victims of Human Rights Violations
TABG	Tim Ahli Bangunan Gedung	Building Construction Expert Team
TKPRD	Tim Koordinasi Penataan Ruang Daerah	Regional Spatial Planning Coordination Team
UN	Persatuan Bangsa-Bangsa (PBB)	United Nations
UNDP	—	United Nations Development Programme
UNFPA	—	United Nations Fund for Population Activities
UNHCR	—	United Nations High Commissioner for Refugees
UNICEF	—	United Nations International Children's Emergency Fund
WB	Bank Dunia	World Bank
WFP	Program Pangan Dunia	United Nations World Food Programme
WHO	—	World Health Organization
WVI	Wahana Visi Indonesia	World Vision Indonesia
YEU	Unit Gawat Darurat Yakkum	*Yakkum* Emergency Unit

[3] In private hospitals as well as universities, commonly they use the term *Obstetri dan Ginekologi*

Abbreviation	Indonesian Language	English
YPAL	Yayasan Panorama Alam Lestari Kabupaten Poso	*Panorama Alam Lestari* Foundation, Poso Regency
YPI	Yayasan Pusaka Indonesia	Indonesian Heritage Foundation
YSTC	Yayasan Sayangi Tunas Cilik	Save The Children Foundation
Regulation / Plan		
EPMA	Undang-Undang Tentang Perlindungan dan Pengelolaan Lingkungan Hidup	Environmental Protection and Management Law
IMB	Izin Mendirikan Bangunan	Building Permit
KDB	Koefisien Dasar Bangunan	Building Coverage Ratio
KLB	Koefisien Lantai Bangunan	Floor Area Ratio
PERDA	Peraturan Daerah	Local regulation
PP	Peraturan Pemerintah	Government Regulation
PRR	Laporan Kemajuan	Progress Report
RAB	Rancangan Anggaran Biaya	Budget Plan
RDTR	Rencana Detail Tata Ruang	Detailed Spatial Plan
RSNI	Rancangan Standar Nasional Indonesia	Draft Indonesian National Standard
RTRW	Rencana Tata Ruang Wilayah	General Spatial Plan
RTRWN	Rencana Tata Ruang Wilayah Nasional	National spatial plan
RW	Rukun Warga	Neighbourhood unit[4]
SEA	Kajian Lingkungan Hidup Strategis (KLHS)	Strategic Environmental Assessment
SNI	Standar Nasional Indonesia	National Standard of Indonesia
UKL-UPL	Upaya Pengelolaan Lingkungan Hidup dan Upaya Pemantauan Lingkungan Hidup	Environmental Management Efforts and Environmental Monitoring Efforts
ZRB	Zona Rawan Bencana	Disaster Prone Zone
Others		
AP	Rencana Aksi	Action Plan
APBN	Anggaran Pendapatan dan Belanja Negara	State budget
ASTER	—	Advanced Space-borne Thermal Emission and Reflection
Banpem	Bantuan Pemerintah	Government Assistance
BARRATAGA	Bangunan Rumah Rakyat Tahan Gempa	Earthquake Resistant Housing
BBB	Membangun Kembali dengan Lebih Baik	Build Back Better
BCP	Rencana Kelanjutan Bisnis	Business Continuity Plan
BLM	Bantuan Langsung Masyarakat	Community Direct Assistance
BMS	Sistem Manajemen Jembatan	Bridge Management System
BoQ	—	Bill of Quantity
BTP	—	Brownian Passage Time
BUMDes	Badan Usaha Milik Desa	Village-Owned Company
BWP	Bagian Wilayah Perencanaan	Part of the Planning Area
C/P	—	Counter Part
CBD	Kawasan Niaga Terpadu	Central Business District
CCT	Pembayaran Tunai Bersyarat	Conditional Cash Payment
CRED	—	Centre for Research on the Epidemiology of Disasters
CSO	Organisasi Masyarakat Sipil (ORMAS)	Civil Society Organization
CSR	Tanggungjawab Sosial Korporat	Corporate Social Responsibility

[4] In urban area (especially Java Island), RW is a neighbourhood unit below Village Level. Smaller unit is RT (Rukun Tetangga). 1 RT consist of 10-50 Households and 1 RW consist up to 10 RT.

Abbreviation	Indonesian Language	English
DED	—	Detail Engineering Design
DEM	—	Digital Elevation Model
DFR	Draf Laporan Akhir	Draft Final Report
DG	Direktur Jenderal (Dirjen)	Director General
DRR	Pengurangan Risiko Bencana (PRB)	Disaster Risk Reduction
DTM	—	Digital Terrain Model
EIA	Analisis Mengenai Dampak Lingkungan (AMDAL)	Environmental Impact Assessment
EMP	Rencana Pengelolaan Lingkungan	Environmental Management Plan
EMoP	Rencana Pemantauan Lingkungan	Environmental Monitoring Plan
ER	Tanggap Darurat (TD)	Emergency Response
ESMF	—	Environmental and Social Management Framework
EWS	Sistem Peringatan Dini	Early Warning System
EXPO	—	Exposition
FGD	—	Focus Group Discussion
FLSH		
FR	Laporan Akhir	Final Report
F/S	Studi Kelayakan	Feasibility Study
G/A	Perjanjian Hibah	Grant Agreement
GBV	—	Gender-Based Violence
GC	Kondisi Umum	General Conditions
GERTASKIN	Program Gerakan Pengentasan Kemiskinan	Poverty Alleviation Program
GIS	Sistem Informasi Geografis (SIG)	Geographic Information System
GL	Panduan	Guide Line
GRP	Produk Regional Bruto	Gross Regional Product
HIV	—	Human Immunodeficiency Virus
Huntap	Hunian Tetap	Permanent Relocation Site
Huntara	Hunian Sementara	Temporary Housing Site
ICR	Laporan Awal	Inception Report
IDR	Rupiah	Indonesian Rupiah
ITR	Laporan Sementara	Interim Report
IKM	Industri Kecil Menengah	Small and Medium Industries
IMB	Ijin Mendirikan Bangunan	Procedures of building permit
IPAL	Instalasi Pengolahan Air Limbah	Wastewater Treatment Plant
IPLT	Intalasi Pengelolaan Limbah Tinja	Faecal sludge treatment plant
ITB	—	Instructions to Bidders
IUMK	Izin Usaha Mikro Kecil	Micro Small Business Permit
JET	—	Japan Exchange and Teaching
KRK	Keterangan Rencana Kota	City Plan Description
L/A	Perjanjian Pinjaman	Loan Agreement
LGBTQ+	—	Lesbian, Gay, Bisexual, Transgender, Questioning, etc.
LLC	—	Level Luffing Crane
Linsek	Lintas Sektor	Inter Sector
LPG gas	—	Liquefied Petroleum gas
MD	Risalah Diskusi	Minutes of Discussion
MEP	Mekanikal, Elektrikal dan Perpipaan	Mechanical, Electrical and Plumbing
M/M	Risalah Rapat	Minutes of Meeting
MKK	Mengawasi Kondisi Konstruksi	Construction supervising works

Abbreviation	Indonesian Language	English
MOU	Nota Kesepahaman	Memorandum of Understanding
M/P	Rencana Induk	Master Plan
MSMEs	UMKM	Micro Small and Medium Enterprises
MTU	Unit Pelatihan *Mobile*	Mobile Training Unit
ODA	—	Official Development Assistance
OP	Keluaran	Output
PASIGALA	Kota Palu, Kabupaten Sigi dan Kabupaten Donggala	Palu city, Sigi Regency and Donggala Regency
PGA	—	Peak Ground Acceleration
PTHA	—	Probabilistic Tsunami Hazard Assessment
PC	Konsultasi Publik	Public Consultation
Persub	Persetujuan Substansi	Substantial Approval (on the Spatial Plan)
POKJA	Kelompok Kerja	Working Team
POKMAS	Kelompok Masyarakat	
PPP	Kebijakan, Rencana dan Program	Policies, Plans and Program
PPs	Proyek Percontohan	Pilot Projects
PQ	Prakualifikasi	Pre-qualification
PRR	Laporan Perkembangan	Progress Report
PSHA	—	Probabilistic Seismic Hazard Assessment
PV	—	Photo Voltaic System
QGC	—	Quay Gantry Crane
RB	Rusak Berat	Severely damaged
RD	Risalah Diskusi	Record of Discussion
R/D	Riset dan Pembangunan	Research and Development
RKPD	Rencana Kerja Perangkat Daerah	Regional Government Work Plans
LARAP	Rencana Aksi Pembebasan Lahan dan Pemindahan Pemukiman	Land Acquisition and Resettlement Action Plan
RRI	—	Rainfall Runoff Inundation
RS	Rusak Sedang	Moderately damaged
RT	Rukun Tetangga	Neighbor Association
SD	Sekolah Dasar	Primary school
SHMs	—	Stakeholder meetings
SLF	Sertifikat Laik Fungsi	Certificate of Building Performance and Function
SMEs	Usaha Kecil dan Menengah (UKM)	Small and medium-sized enterprises
SMP	Sekolah Menengah Pertama	Middle School
SNS	Layanan Jejaring Sosial	Social Networking Service
SOP	Standar Prosedur Operasi	Standard Operational Procedure
SPPL	Pernyataan Kesanggupan Pengelolaan dan Pemantauan Lingkungan Hidup	Statement of Environmental Management and Monitoring Undertaking
TA	Bantuan Teknis (Bantek)	Technical Assistance
ToR	Kerangka Acuan Kerja (KAK)	Terms of Reference
TPA	Tempat pembuangan akhir	Landfill
WASH	Air, Sanitasi, Kebersihan	Water, Sanitation, Hygiene

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VOLUME III Formulation of Spatial Plan Based on Disaster Hazard and Risk Assessment

Chapter-1 Summary of Activities for Output 2 "Spatial Planning Support"

1-1 Background

1-1-1 Master Plan for Recovery and Reconstruction from Central Sulawesi Disasters: Concepts and Approaches of BBB, DRR and Resilience

On the 31st of December 2018, three months after the Palu earthquake, Bappenas and concerned government ministries and agencies[1] formulated and published a master plan for recovery and reconstruction from the Central Sulawesi disasters.[2] The master plan was prepared for guiding the recovery and reconstruction process based on the approach of Build Back Better (BBB). The BBB does not try to achieve a simple recovery, or just to restore what was lost from a disaster. But it aims at creating a "more resilient state" of communities, cities and regions against future disasters. Such disaster resilience is considered to be enhanced not only by planning and implementing disaster risk reduction measures (DRR measures) but also by fostering people's awareness on disaster preparedness.

These concepts and approaches are included in the "Sendai Framework for Disaster Risk Reduction (2015-2030)" agreed at the 3rd UN World Conference on Disaster Risk Reduction in 2015. Since then, BBB, DRR, and resilience have been studied and adopted in various ways around the world, and have composed a mainstream in disaster-related policies and initiatives.

BBB increases the "resilience" of local areas and communities by incorporating and integrating disaster risk reduction measures into strategies and plans to restore and reconstruct physical infrastructure and social systems during the post-disaster recovery and reconstruction stage. [3]

To incorporate the ideas of DRR and resilience in spatial planning and achieve BBB, scientific and accurate information on disaster hazards and risks are required. In line with this, and in order to consider effective measures to increase resilience, it is necessary to pay attention to particular spaces in local areas and communities by preparing and utilizing disaster hazard maps and risk maps.

For considering effective DRR measures in different areas, it is important to understand people's perspectives and awareness of disaster hazards and risks. Therefore, a variety of stakeholders, especially local communities, should be involved in the spatial planning process.

1-1-2 Present Situation of Spatial Planning and Response Measures Considering Disaster Hazards and Risks in Indonesia

Although it is known that there are hazards and risks due to various disaster types (tsunami, active fault, earthquake, flood, sediment disaster, etc.) in the target areas of this Project, any spatial plans

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1 Those related government ministries and agencies include PUPR, BNPB, ESDM, BMKG and BG.
2 The name of the master plan is "Rencana Induk Pemulihan dan Pembangunan Kembali Wilayah Pascabencana Provinsi Sulawesi Tengah" in the Indonesian language.
3 UN Assembly 2016

which substantially incorporated measures against disaster hazards and risks have not yet been formulated. As a result, no disaster risk reduction measures against those disasters, including DRR measures, have been implemented. Moreover, the Palu earthquake disaster was accompanied by serious damages caused by a new disaster called “Nalodo” (liquefaction landslide).

In Indonesia, the 2007 Spatial Planning Act (Law No.27 / 2007) stipulates the formulation of general spatial plans (hereinafter referred to as “RTRW”) at the national, province, city and regency levels, respectively. It is also stipulated that detailed spatial plans (hereinafter referred to as “RDTR”) will be formulated for urbanized areas of cities and regencies. Such formulated spatial plans are statutory plans and become legally effective with the approval of the assembly of individual local government. Each spatial plan is updated every 5 years with a target year of 20 years from the time of formulation. It will also be updated even after the occurrence of abnormal situations, such as catastrophic disasters, like the last Palu earthquake disasters.

A guideline for the formulation of RTRWs for provinces, cities and regencies (ATR Ministerial Ordinance No. 1 /2018) and another one for the formulation of RDTRs (ATR Ministerial Ordinance No. 16/ 2018) have been established. Although these guidelines state the importance of considering disaster hazards and risks when formulating spatial plans, they do not sufficiently provide any specific ideas and methodologies for that purpose.

In technical cooperation with the central government ministries and local governments in Indonesia, Output 2 is to provide concepts and concrete methods for spatial planning for the purpose of increasing disaster resilience by incorporating disaster reduction measures in specific locations in consideration of disaster hazard maps and risk maps.

1-2 Goals, Objectives and Targets

1-2-1 Goals of Output 2 “Spatial Planning Support”

Considering the above-mentioned background, in order to promote recovery and reconstruction of target areas from the last catastrophic disaster in Palu and its surrounding areas, it is necessary to renew spatial plans for achieving the following goals in line with the principle of Build Back Better:

- Following the master plan for recovery and reconstruction from the last Central Sulawesi disasters, the implementation of spatial plans to be formulated through technical cooperation of this Project are not only to guide short-term recovery and medium and long-term reconstruction in Central Sulawesi Province, especially in Palu Metropolitan Area, but also to enhance disaster resilience of the target areas against future disasters.

1-2-2 Objectives of Output 2 “Spatial Planning Support”

The objective of Output 2 for “Spatial Planning Support” is to provide technical assistance to ATR and local governments in the formulation of spatial plans considering disaster hazards and risks in the post-disaster context, in order to achieve the goals mentioned above.

1-2-3 Targets of Output 2 “Spatial Planning Support”

The target spatial plans for technical assistance in Output 2 are as follows:

- Palu City RTRW
- Palu City RDTR
- Sigi Regency RTRW
- Sigi Regency's Bora RDTR
- Donggala Regency's Banawa RDTR

1-2-4 Roles of ATR, Local Governments, Bantek Consultants, JICA Study Team and JICA Experts in Spatial Planning

There are various organizations and actors who have been directly and indirectly engaged in the formulation of spatial plans considering disaster hazards and risks in the target areas. They played different kinds of roles in spatial planning as follows:

(1) ATR

The spatial planning processes by local governments and Bantek consultants were carried out under the guidance of ATR in accordance with existing guidelines for formulating RTRW and RDTR. ATR assigned a person in charge of each spatial planning operation in order to manage, supervise, and monitor the spatial planning work and procedures of local governments and Bantek consultants, and provided necessary advice. At the same time, with the cooperation of central government agencies, ATR collected and analyzed information on various disaster hazards. ATR has compiled ZRB maps that suggest policies for land use regulations and building structural requirements by disaster type and disaster hazard level.

ATR has instructed local governments and Bantek consultants to formulate spatial plans based on disaster hazards and risks using the ZRB maps that it compiled. In addition, ATR coordinated with relevant central-level ministries and agencies in the official procedure of ensuring that each spatial plan is consistent with various central-level sector policies. Based on these management and coordination procedures, ATR is officially to approve spatial plans formulated by Bantek consultants and local governments.

(2) Local Governments

Local governments are the major constituents responsible for formulating spatial plans in their areas, and the owners of these plans. After spatial plans are formulated under the responsibility of the local governments, they are submitted to ATR with the recommendation of the provincial governor. The submitted spatial plans are to be examined by ATR if they are consistent with central-level sector policies and strategies. The submitted spatial plans are to be modified by considering advice made by central-level sector agencies, as well as by the ATR. Then the modified spatial plans are returned to respective local governments after approval by the Minister of ATR after an inter-sectoral coordinating meeting (LINSEK meeting) with the central-level related ministries and agencies hosted by ATR and subsequent coordination. After that, the local regulations related to the spatial plan are deliberated by the local assembly, and after adjustment and amendment, they are officially approved and enforced as the local regulations.

For the spatial planning process, each local government establishes a space planning committee to carry out various procedures. In addition, various meetings (Focus Group Discussion meetings, Public Consultation meetings, etc.) in the spatial planning process are held by local governments by inviting relevant parties. The actual technical work involved in planning will be done by the Bantek consultant, while the local government will make important directions and decisions at each step.

(3) Bantek Consultants

Bantek consultants are private consultant teams entrusted with spatial planning work by a central-level ATR. They are responsible for collecting and analyzing information, and formulating spatial plans, while preparing and organizing meetings at different stages of spatial planning process. Bantek consultants are to be engaged in this spatial planning work, while receiving instructions from the ATR officer in charge of each spatial plan, and discussing and coordinating with the local government officers in charge of the spatial plan. They are also responsible for conducting Strategic Environmental Assessment (SEA) for target spatial plans.

(4) JICA Experts

JICA Experts technically guided and provided explanations to the JICA Study Team and had technical discussions with Bappenas, ATR, local governments, and Bantek consultants. In particular, they played central roles in Activity 3, Activity 4, and Activity 6 described below.

(5) JICA Study Team

For achieving the goals and objectives of the Project, Output 2 "Spatial Planning Support" is to provide technical assistance to ATR and local governments through the following activities:

- Activity 1: Review of Existing and Draft Spatial Plans (RTRWs)
- Activity 2: Review of Existing and Draft Detailed Spatial Plans (RDTRs)
- Activity 3: Provision of Support for the Ministry of Land and Spatial Planning (ATR) and Local Governments to Formulate RTRWs and RDTRs
- Activity 4: Provision of Support for the Ministry of Land and Spatial Planning (ATR) and Local Governments to Formulate, Improve and Enforce Land Use Regulation and Building Regulation
- Activity 5: Provision of Support for Strategic Environmental Assessment (SEA) in Spatial Planning Process
- Activity 6: Preparation of Reference Manuals (Guidelines) for Formulating Spatial Plans Based on Disaster Risk Reduction

The JICA Study Team started the activities of Output 2 "Spatial Planning Support" in January 2019. Prior to the beginning of the official spatial planning process (July 2019), some of the above-mentioned activities, Activity 1, Activity 2 and Activity 3, were implemented. During the official spatial planning period (July to December 2019), Activity 3, Activity 4, Activity 5, and Activity 6 were carried out. After that, from January to February 2020, the JICA Study Team followed up on the spatial planning process. Furthermore, after March 2020, the approval procedures for formulated spatial plans were monitored. A description of specific activities for each phase is given in the next section.

Figure 1-1 shows the relationship between the activities of Output 2 by the JICA Study Team and the official spatial planning process by ATR and local governments. From the JICA Study Team, 1) spatial development concepts that include land use regulations and building structure requirements, 2) methodology and results of community dialogues, 3) results of building damage surveys, 4) methodologies of ZRB boundaries and additional regulations, and 5) various other spatial planning methodologies were provided to different stages of the official spatial planning.

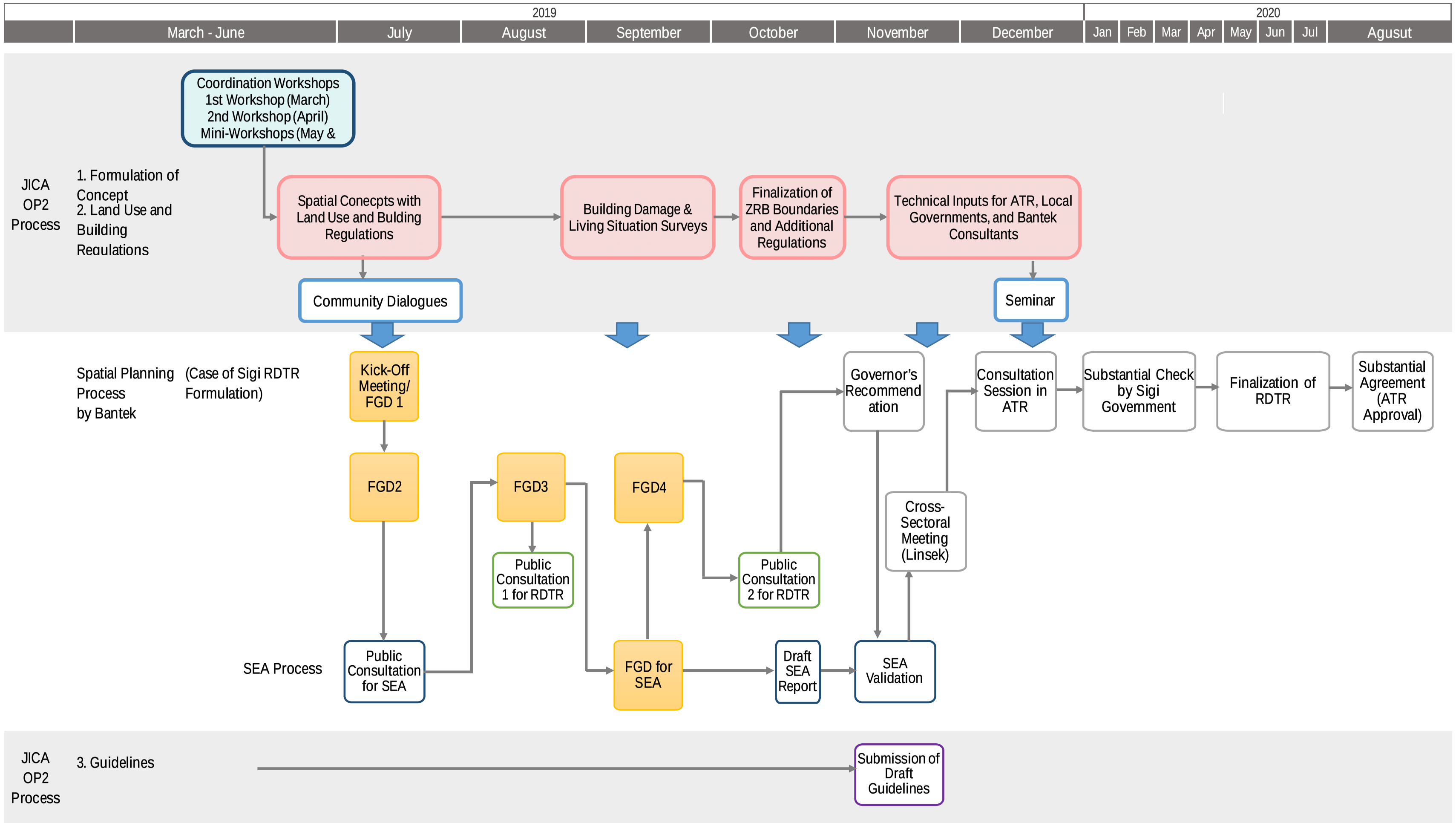
1-3 Phases and Actual Activities of Output 2 "Spatial Planning Support"

In the Project, Output 2 activities were carried out in the following five phases:

1-3-1 Phase 1: From January 2019 until June 2019

At the preparatory stage prior to the official spatial planning: Activity 1, Activity 2 and part of Activity 3 were conducted covering the following aspects:

- Analysis of past trends of population and urbanization
- Analysis of spatial development directions by reviewing existing spatial plans and other development plans
- Preparation of alternative spatial development concepts for future reconstruction based on the concepts of BBB and DRR in four largely affected areas by the last disasters, considering the situation of disaster hazards and disaster risks
- Holding of preparatory workshops on spatial planning for the purpose of training government officers involved in this, including those in ATR, PUPR, and local governments. The workshops are opportunities to explain and discuss characteristics of disaster hazards and alternative spatial development concepts.



Source: JICA Study Team

Figure 1-1 Relationship between Official Spatial Planning Process and Activities of Output 2 "Spatial Planning Support" of the JICA Study

1-3-2 Phase 2: From July 2019 until October 2019

The JICA Study Team provided technical support (explanation and consultation) to local governments, ATRs, and Bantek consultants during the official spatial planning process (consisting of FGD1 through FGD5 and Public Consultation 1 and Public Consultation 2). Specifically, the JICA Study Team examined and proposed methods concerning the following aspects, and explained and discussed contents of the formulated spatial plans:

- Implementation of building damage surveys related to tsunami, Nalodo, and active faults
- Recommendations on how to determine ZRB boundaries (especially ZRB4 boundaries)
- Creation and proposing of actual ZRB boundaries
- Recommendation of concepts for additional regulations on land uses and building structures by each disaster type and disaster hazard
- Preparation and proposing of actual additional regulations on land uses and building structures
- Recommendation of methods for formulating spatial development concepts by utilizing disaster hazard maps and disaster risk maps
- Creation and proposal of actual spatial development concepts
- Recommendations to the SEA process for spatial planning at different stages

1-3-3 Phase 3: From November 2019 until December 2019

Technical follow-up and coordination were done by conducting the following activities concerning the formulated spatial plans:

- Examination and recommendation of concrete methods for incorporating three important methodologies (utilization of disaster hazard maps and risk maps for formulating spatial development concepts, setting of ZRB boundaries, and formulation of additional regulations on land uses and building structures) in the formulation of spatial plans (RTRWs and RDTRs)
- Explaining and discussing of those concrete methods and results with ATR, local governments, and Bantek consultants

1-3-4 Phase 4: From January 2020 until February 2020: Discussion and Coordination Regarding the Extension of the Period for Output 2 Activities for “Space Planning Support”

(1) Explanation and Discussion at the 3rd JCC on December 11, 2019

At the 3rd JCC meeting, the JICA Study Team raised some important issues in the formulation of spatial plans by ATR, Bantek consultants, and local governments. The JICA Study Team pointed out difficulties for local governments and Bantek consultants to establish scientific and socially acceptable spatial plans.

Spatial Plan	Remaining Issues
Palu City RDTR	• Reconsideration of ZRB4 boundaries, including coastal buffer zones, is required • Preparation of additional regulations responding to disaster types and hazard levels is necessary.
Sigi Regency's Bora RDTR	• Reconsideration of ZRB4 boundaries of Lolu is needed. • Preparation of additional regulations responding to disaster types and hazard levels, especially building structural requirements, is required.
Donggala Regency's Banawa RDTR	• None (settled already)

Source: JICA Study Team

These issues were not only identified by the JICA Study Team reviewing the spatial plans formulated by ATR, Bantek consultant and local governments. They were also raised in the TKPRD meeting (coordination meeting) on the provincial governor's recommendation for the spatial plans, and those points were recorded in the official minutes of the TKPRD meeting. Then official letters were sent by local governments and PUPR to convey those issues to Bappenas.

As a solution to these issues, the JICA Study Team proposed to extend the period of Output 2 activities for spatial planning support for about two to three months at the beginning of 2020. During that period, the JICA Study Team also proposed to conduct a survey of residents' intention to relocate from ZRB4 areas and to revise the spatial plans based on the survey results.

In response, the participants of the 3rd JCC meeting generally agreed with the remaining issues pointed out by the JICA Study Team. JCC Chairman of Bappenas replied that Indonesian officials would coordinate and consider a policy on this matter, and contact JICA regarding the proposal to extend the period of Output 2 activities.

(2) Explanation and Discussion with Bappenas on January 8, 2020

At the beginning of 2020, the JICA Study Team requested Bappenas to have a meeting because there had been no response from the Indonesian side to the proposal by the JICA Study Team at the 3rd JCC. The opinions expressed by Bappenas at the meeting on the 8th of January 2020 were as follows:

- By conducting Residents' Intention Survey or Situation Survey, the JICA Study Team will be able to continue to provide technical support to local governments so that they could reflect their opinions to revise ZRB maps and spatial plans.
- Based on the above survey results, it is necessary to hold coordinating meetings with ATR and related organizations to agree on a revised version of ZRB maps to be technically supported by the JICA Study Team. Then local governments will be able to revise their spatial plans by using these revised ZRB maps with technical support of the JICA Study Team.

(3) Explanation and Discussion with ATR on January 15, 2020

Regarding the implementation of Residents' Intention Survey and the extension of the period for Output 2's technical support proposed by the JICA Study Team at the 3rd JCC in December 2019, the JICA Study Team requested ATR Director of Spatial Planning, to hold a meeting in order to check ATR's opinions. The director expressed her opinion that ATR does not need the JICA Study Team's technical support to conduct an additional survey for inquiring into residents' intentions about relocation from ZRB4 areas within this Project. Since they need to speed up the finalization of the spatial plans and local regulations on the spatial plans, they do not seem to have sufficient time to utilize survey results for revising ZRB maps and finalizing the spatial plans.

(4) End of Output 2 Activities

Based on the results of these meetings with Bappenas and ATR, it was decided that Output 2 activities for spatial planning support would be completed by the end of February 2020, while the monitoring of approval procedures for the formulated spatial plans continues.

After that, an updated version of the Recommendation Report on spatial planning was prepared and submitted to ATR, central-level related organizations and local governments in February 2020, and it was explained to them that Output 2 activities would be completed at the end of February.

1-3-5 Phase 5: From March 2020 until April 2021: Monitoring of Approval Procedures for Spatial Plans

(1) Approval Procedures for Spatial Plans

Strategic Environmental Assessments (SEAs) for draft spatial plans by local governments of provinces, cities and regencies need to be approved by the Provincial Environmental Department as one of the requirements for finalizing the formulation of these plans. With that approval, the next stage is the holding of a coordinating meeting (Linsek) with relevant sectoral ministries at the central level. After responding to comments and correction requests made at the Linsek meeting, an approval (Persub) from ATR will be issued. After the Persub, the spatial plans are to be returned to their respective local governments for deliberation in the local parliaments. After that, there is an approval procedure for regional regulations (Peraturan Daerah) related to spatial plans.

(2) Situation of Approvals of Spatial Plans and Local Regulations on Spatial Plans

The ATR's approval (Persub) of Palu City RTRW was completed on the 25th of June 2020, and Palu City RDTR completed its Persub on the 3rd of October 2020. The Persub for Sigi Regency RTRW was finished on the 1st of August 2020, and Bora RDTR in Sigi Regency was approved by ATR (Persub) on the 6th of October 2020. The Persub approval of Banawa RDTR in Donggala Regency was completed in August 2020. Hence, the Persub approvals of the spatial plans were far behind the initial target (November or December 2019).

According to information as of end of April 2021, only Sigi Regency's parliament finished the deliberation and approval of regional regulations regarding Sigi Regency RTRW. The deliberation on regional regulations for the other spatial plans have not yet been done by the local parliaments. It was partly because they considered it necessary to follow a new guideline on spatial planning to be issued by the ATR to comply with the Omnibus Law for Job Creation (CIKA Law).

1-4 Technical Approach for Formulating Spatial Plans Based on Disaster Hazards and Risk Assessment

In order to spatially consider disaster hazards and risks and improve disaster resilience, the following approaches are adopted:

1-4-1 Creation of Spatial Development Concepts Based on the Examination of Spatial Development Directions in the Palu Metropolitan Area

In the target areas, spatial development concepts are to be formulated by considering development potential and constraints, as well as the disaster hazards in a spatially integrated manner. See Chapter 3.

In Indonesia, spatial plans are to be formulated for each administrative unit at the national, provincial, city and regency levels. However, if urbanization is progressing in surrounding areas beyond the boundaries of the central city, it is necessary to consider the whole urbanized and urbanizing areas as one metropolitan area. Then it is necessary to analyze directions and degrees of spatial development within the metropolitan area. (See Section 3-2.)

1-4-2 Alternative Spatial Development Concepts to Improve Disaster Resilience

In order to formulate effective measures to improve disaster resilience of the target areas, the JICA Study Team proposes to combine non-structural and structural measures by utilizing both disaster hazard maps and risk maps.

In order to identify the areas where DRR measures will be taken using costly structures, it is important to use a disaster risk map by combining disaster hazard maps and the distribution pattern of population and assets. (See Section 3-2-3.)

1-4-3 Creation of ZRB Maps Based on Disaster Hazard Maps and Incorporation of Additional Regulations in Spatial Plans

Based on scientifically prepared disaster hazard maps, it is necessary to refine ZRB maps that show general policies on land use regulations and building structure requirements for each disaster type and each disaster hazard level. Such ZRB maps should be prepared by using four hazard levels for the post-disaster contexts. In the post-disaster contexts, it is important to identify the areas of the highest hazard levels (ZRB4 areas), which should be non-development zones. In ZRB4 areas, inhabitants are recommended to be relocated.

In order to determine the boundaries of the highest hazard levels (ZRB4), the following three survey and study results of the last disasters are utilized. (See Section 4-5-2.)

- Results of disaster damage surveys
- Results of scientific studies about disaster hazard levels
- Results of residents' intention to relocate survey

1-4-4 Incorporation of Land Use Regulations and Building Structural Requirements in Land Use Zoning Plans

Land use regulations and building structure requirements are to be stipulated for each disaster type and each disaster hazard level, and these regulations should be incorporated in land use zoning plans. (See Sections 4-10 and 4-11.)

Chapter-2 Review Existing and Draft Spatial Plans in Selected Areas

2-1 Approach and Contents of Output 2 Technical Assistance for ATR and Local Governments

The review of and feedbacks on existing spatial plans and draft spatial plans under formulation were presented and discussed in the coordination workshop and mini-workshops held by the local governments and JICA Study Team. The review was conducted by overlaying the existing spatial plans and new draft land use plans on ATR's ZRB map and on the hazard maps JICA Study Team. If residential or commercial areas are allowed in high disaster risk areas (ZRB4 areas), the JICA Study Team proposes restrictive land use regulations or other land uses (such as agricultural land use) in these areas for curbing urban development.

2-2 Review of Existing and Draft Spatial Plans (RTRWs)

The review of RTRWs examined the disaster hazard and risk analysis, land use and infrastructure development policies (including evacuation facilities and routes) in these plans from the perspective of DRR.

2-2-1 Assessment of Disaster Hazards and Risks

In each plan of RTRWs, disaster hazard types, such as landslide, earthquake (active faults), liquefaction, tsunami, and wave/coastal erosion, are assessed based on the data prepared by BMKG, BNPB, BIG, BG, and others. Draft RTRWs under revision or preparation were also reviewed in the light of the September 2018 disaster situation. The plans that were reviewed are as follows:

(1) Central Sulawesi Province RTRW 2013-2033

In the RTRW 2013-2033 of Central Sulawesi Province, "prone areas" are defined for different natural disasters. The same has been done in the other RTRWs.

- Earthquake-prone areas are those which have the potential or have experienced earthquakes.
- Areas prone to land movement are areas that have a high level of vulnerability to land movement.
- Areas located in active fault zone are determined by the presence of the border with the lowest width of 250 meters from the edge of an active fault line.
- Tsunami-prone areas are determined by the presence of low-elevation coast which has potential or had experienced a tsunami.
- Areas prone to abrasion are determined by the presence of a coast that has the potential or has experienced abrasion.

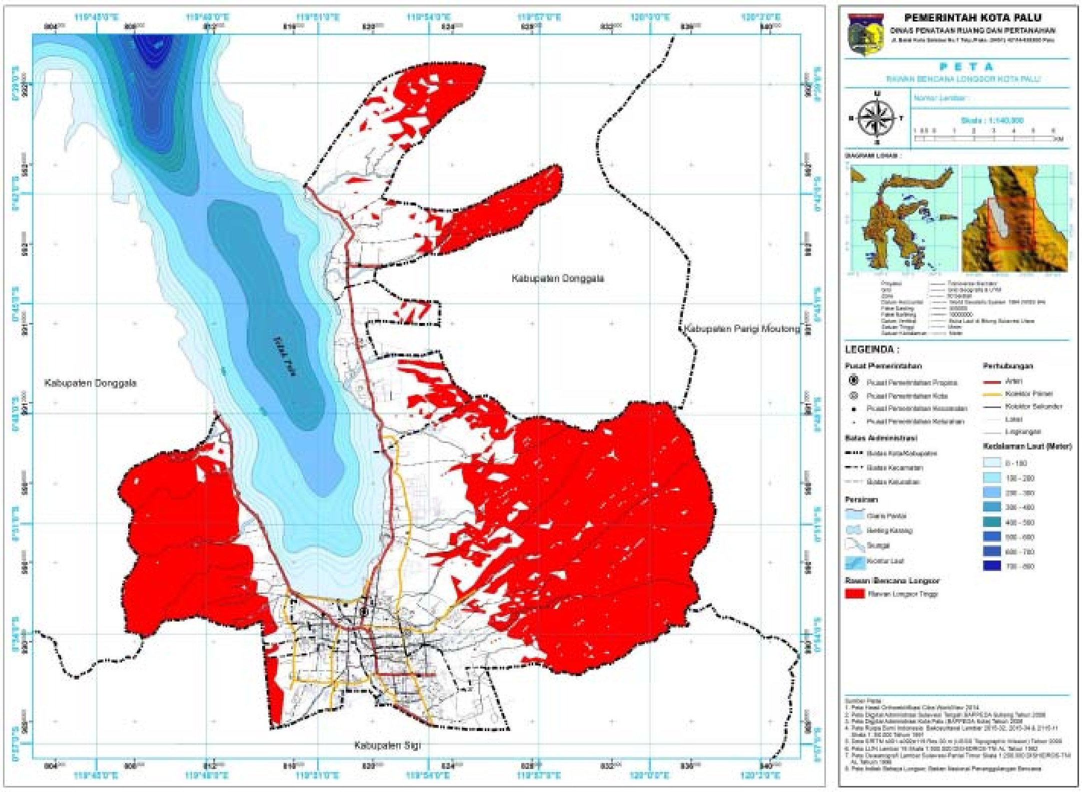
(2) Palu City RTRW 2010-2030 and Draft RTRW 2018-2038

- Landslide: In the RTRW 2010-2030, the upper stream of Watutela River as well as the sub-districts of Silae, Kabonena and Donggala Kodi have been designated as landslide-prone areas. In addition, Manukulore Sub-district and Ulujadi Sub-district are specified as landslide-prone areas (protected areas). Furthermore, the vulnerability to landslide of Palu Utara Sub-district and Tawaeli Sub-district is pointed out in RTRW 2018-2038 under revision. It should be noted that these revisions in the RTRW were proposed based on the damage situation caused by landslides in 2018.

Table 2-1 Damage Caused by the 2018 Landslide Disaster in Palu City

No.	Sub-district	Risk of Landslide	Area (Ha)
1	Palu Barat	High	728.02
2	Tatanga	High	1,517.01
3	Ulujadi	High	6,344.63
4	Palu Selatan	High	1,955.24
5	Palu Timur	High	614.38
6	Mantikulore	High	19,251.60
7	Palu Utara	High	3,010.64
8	Tawaeli	High	6,084.48
		Total	**39,506.00**

Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018



Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018 (Draft)

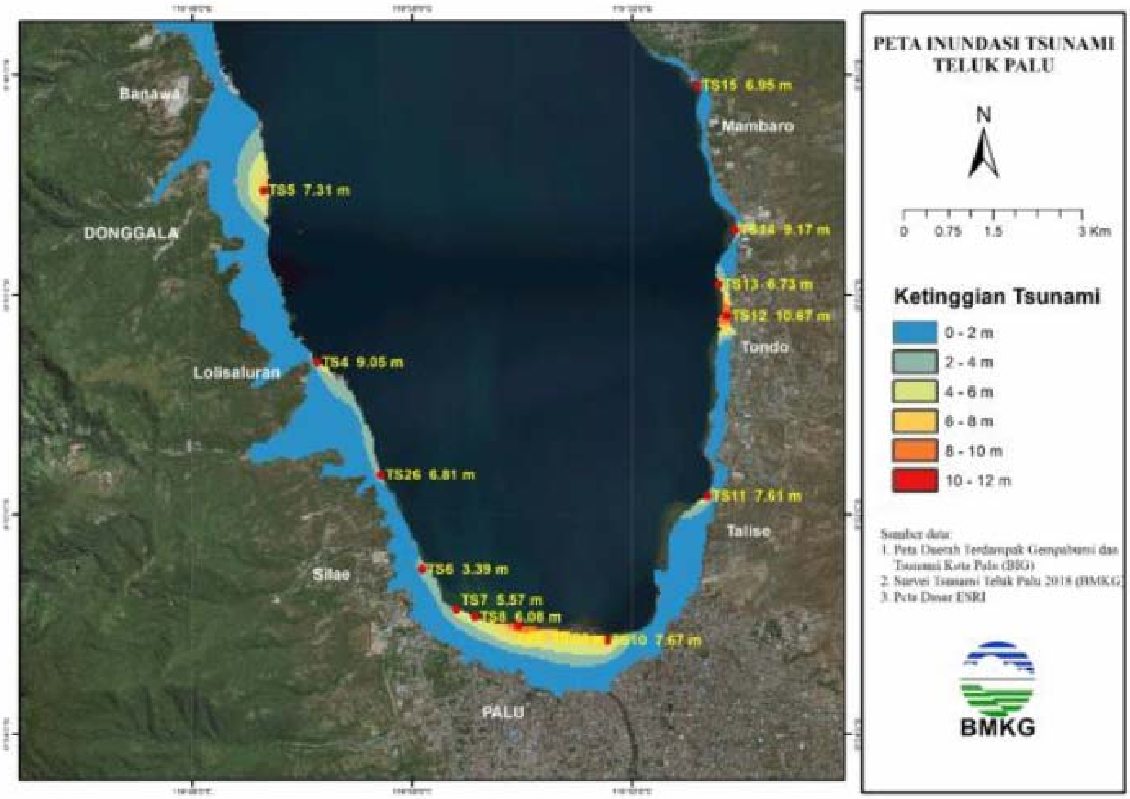
Figure 2-1 Landslide Hazard Map (Palu City Draft RTRW 2018-2038)

- Tsunami: In the RTRWs, the mechanism of tsunami occurrence has been specified based on considerations of fault activities and the data of tsunami and earthquake occurrences in Sulawesi Island from 1820 to 2006. In addition, based on the data of BMG Palu, tsunami-prone areas were identified in the RTRW. In the RTRW under revision, additional tsunami-prone areas are specified by using data of BMG Palu of 2018. The list of these areas is shown in Table 2-2.

Table 2-2 Tsunami-Prone Areas in Palu City in the RTRW Revision

No.	Sub-district	Villages Prone to Tsunami
1	Tawaeli	Boya Pantaloan, Pantaloan, Baiya, Panau
2	Palu Utara	Kayumalue Pajeko, Taipa, Mamboro, Mamboro Barat
3	Mantikulore	Layana Indah, Tondo, Talise
4	Palu Timur	Besusu Tengah, Besusu Barat
5	Palu Barat	Lere
6	Ulujadi	Kabonena, Silae,Tipo, Buluri, Watusampu

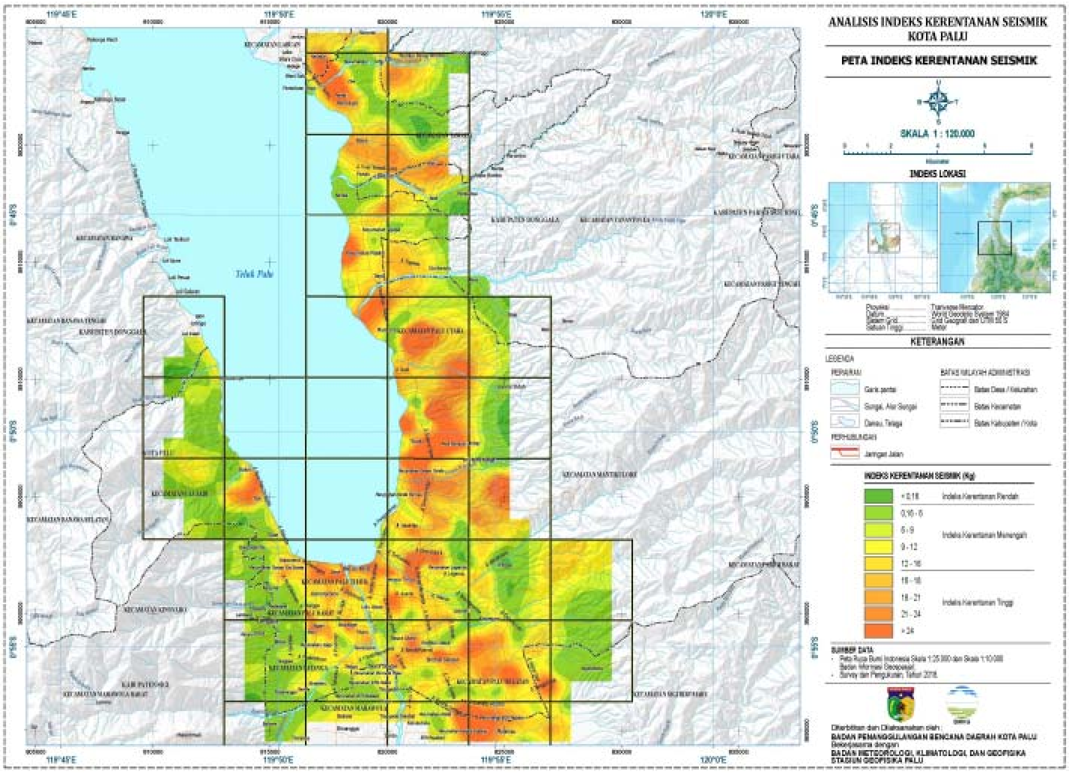
Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018



Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018 (Draft)

Figure 2-2 Tsunami Hazard Map (Palu City Draft RTRW 2018-2038)

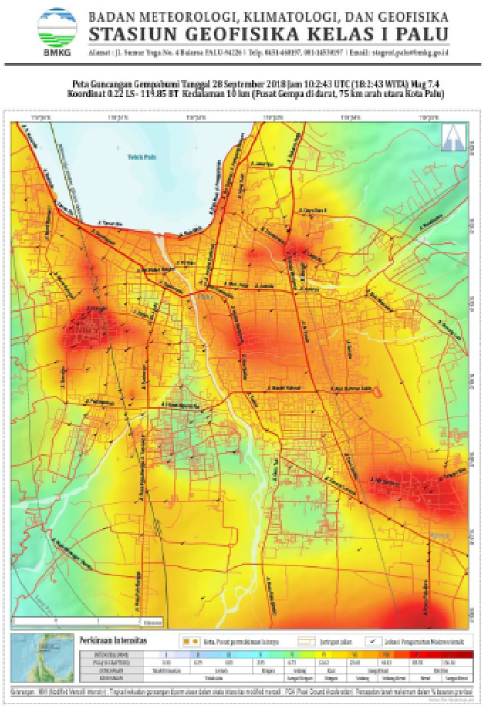
- Earthquake: The mechanism of earthquakes that occurred due to active faults of Palu-Koro and Pasternoster was specified. In the RTRW 2010-2030, high risk areas near the fault line have been specified. Meanwhile, 20-meter buffer zones from the active faults are set in the sub-districts of Tatanga, Ulujadi and Palu Barat.



Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018 (Draft)

Figure 2-3 Earthquake Hazard Map (Palu City Draft RTRW 2018-2038)

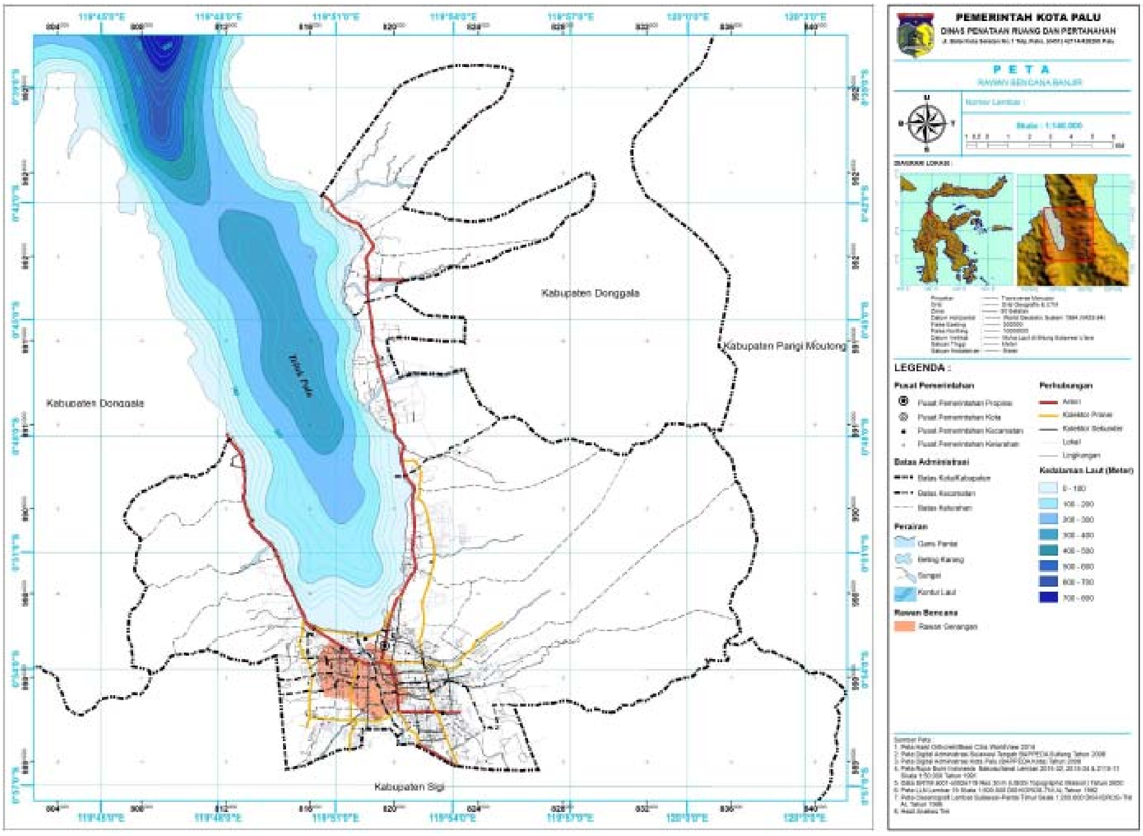
- Liquefaction: Liquefaction has been considered in the RTRW under revision. High risk areas of this disaster type have been listed based on the damage situation of Petobo Sub-district and Balaroa Sub-district in 2018.



Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018 (Draft)

Figure 2-4 Liquefaction Hazard Map (Palu City Draft RTRW 2018-2038)

- Flood: Flash flood is specified as a main feature of flooding in Palu City. In addition, the features of different rivers from the standpoint of flood occurrence are summarized in the RTRWs.



Source: Revisi Rencana Tata Ruang Wilayah Kota Palu 2018 (Draft)

Figure 2-5 Flood Hazard Map (Palu City Draft RTRW 2018-2038)

(3) Sigi Regency RTRW 2010-2030 and Draft RTRW 2018-2038

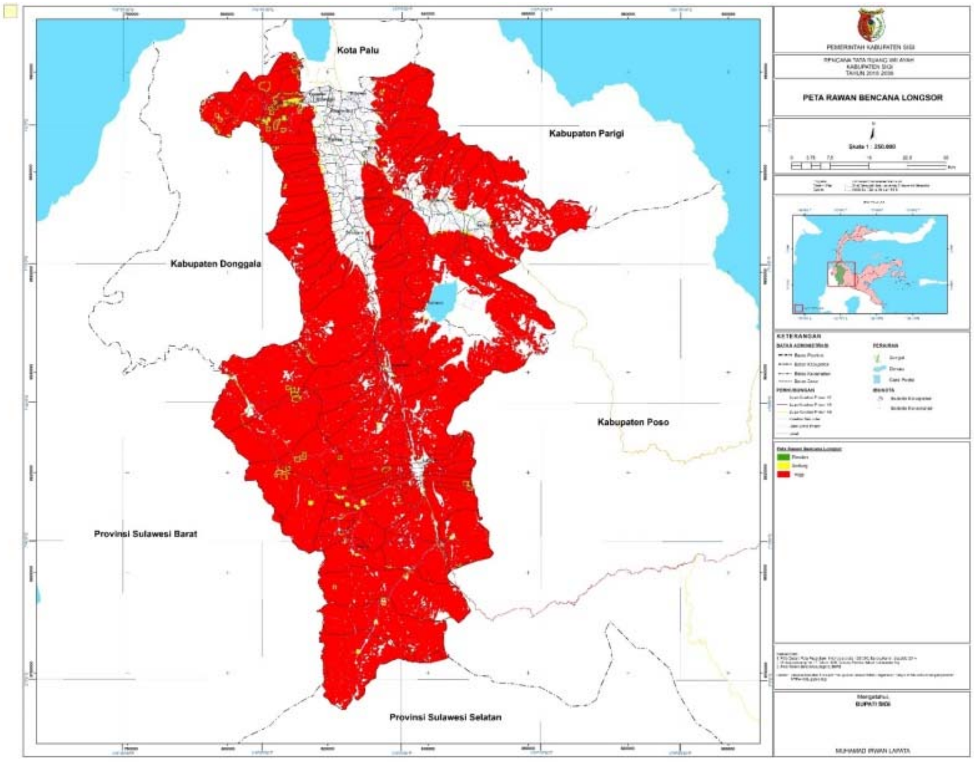
- Landslide: According to the RTRW under revision, Sigi Regency has 14 sub-districts out of 15 sub-districts which are high risk to landslide disaster. They were listed based on the map of landslide risk in 2018 edited by BNPB. One sub-district classified as safe from landslide occurrence is Dolo.

Table 2-3 Landslide-Prone Areas in Sigi Regency

No.	Sub-district	Risk of Landslide	Area (Ha)
1	Pipikoro	High	8,646.00
2	Kulawi Selatan	High	852.60
3	Kulawi	High	5,861.37
4	Lindu	High	1,694.38
5	Nokilalaki	High	78.99
6	Gumbasa	High	457.19
7	Dolo Selatan	High	2,059.76
8	Tanambulava	High	14.04
9	Dolo Barat	High	111.72

No.	Sub-district	Risk of Landslide	Area (Ha)
10	Palolo	High	3,678.81
11	Marawola	High	26.09
12	Marawola Barat	High	905.96
13	Sigi Biromaru	High	5,306.41
14	Kinovaro	High	461.80
		Total	**30,155.11**

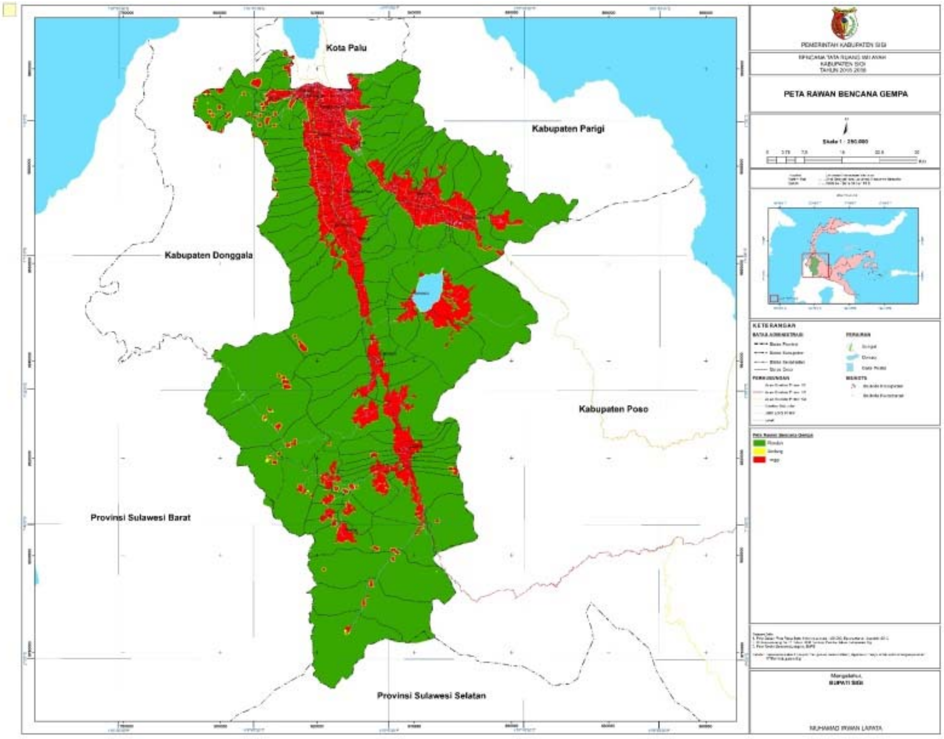
Source: Peta Resiko Bencana Longsor, BNPB Tahun 2018



Source: Rencana Tata Ruang Wilayah Kabupaten Sigi 2018-2038 (Draft)

Figure 2-6 Landslide Hazard Map (Sigi Regency Draft RTRW 2018-2038)

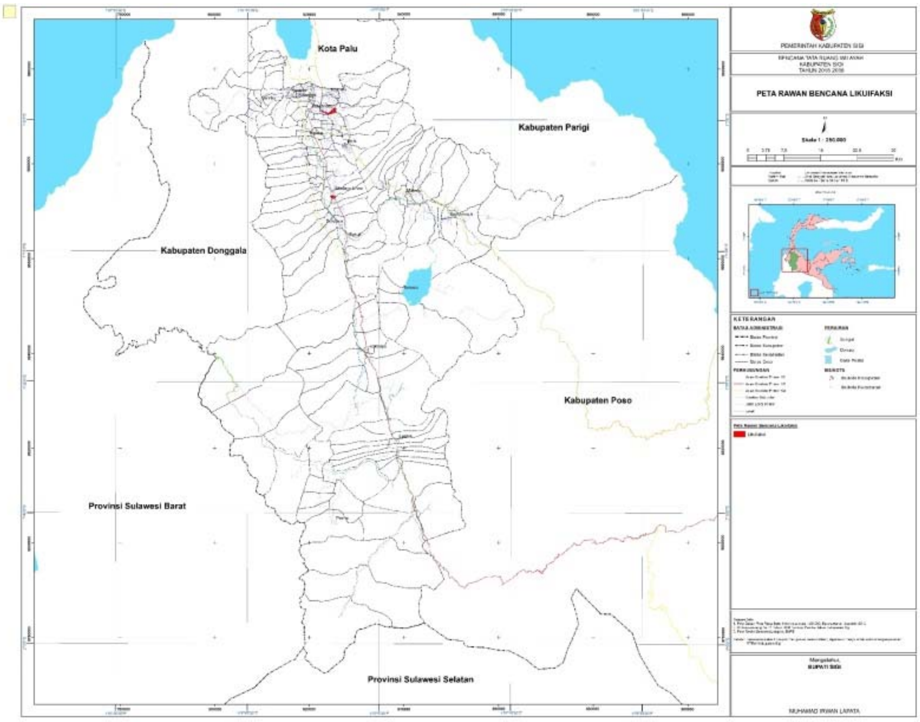
- Earthquake: Based on Indonesia's earthquake risk data, it was stated that Sigi Regency has a high earthquake risk with particular reference to Palu-Koro fault.



Source: Rencana Tata Ruang Wilayah Kabupaten Sigi 2018-2038 (Draft)

Figure 2-7 Earthquake Hazard Map (Sigi Regency Draft RTRW 2018-2038)

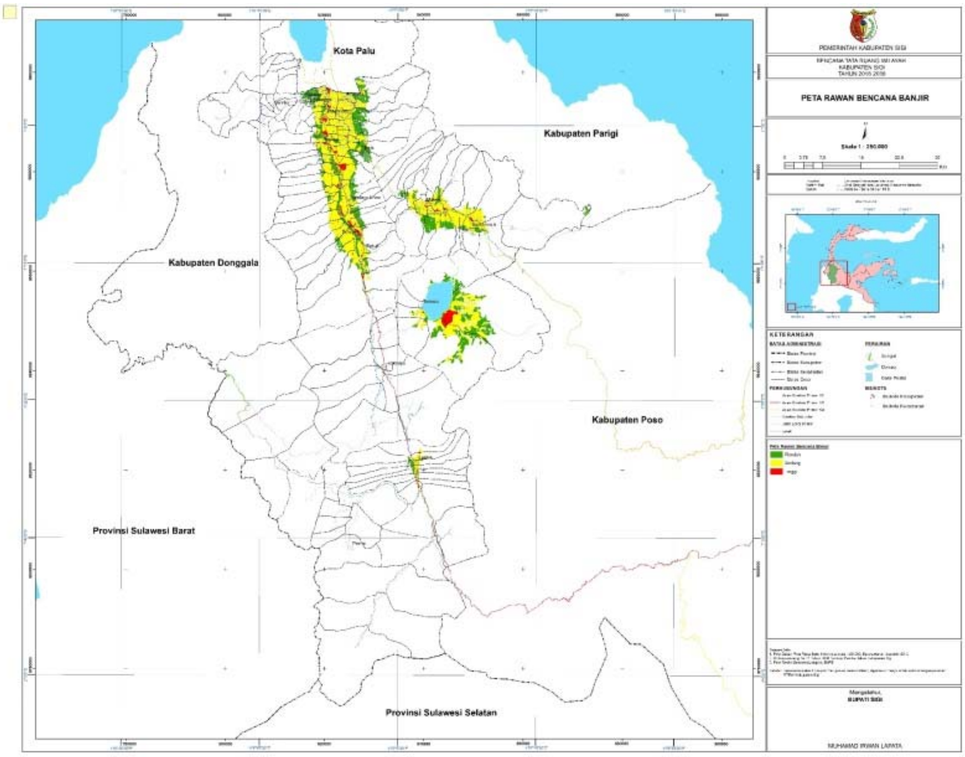
- Liquefaction: Liquefaction has been considered in the RTRW under revision. High risk areas of liquefaction disaster have been listed based on the damage situation of Sigi Biromaru Sub-district and Jono Oge Sub-district in 2018.



Source: Rencana Tata Ruang Wilayah Kabupaten Sigi 2018-2038 (Draft)

Figure 2-8 Liquefaction Hazard Map (Sigi Regency Draft RTRW 2018-2038)

- Flood: It was pointed out that floods are caused by several factors, such as the tendency to overuse forests, which lead to erosion and deposition of the Palu River. Based on the flood disaster risk map of BNPB of Sigi Regency, the high risk areas are the sub-districts of Marawola, Sigi Biromaru, Dolo, Dolo Barat, Dolo Selatan, Tanambulava, Gumbasa, Palolo, Nokilalaki, Lindu, and Kulawi Selatan.



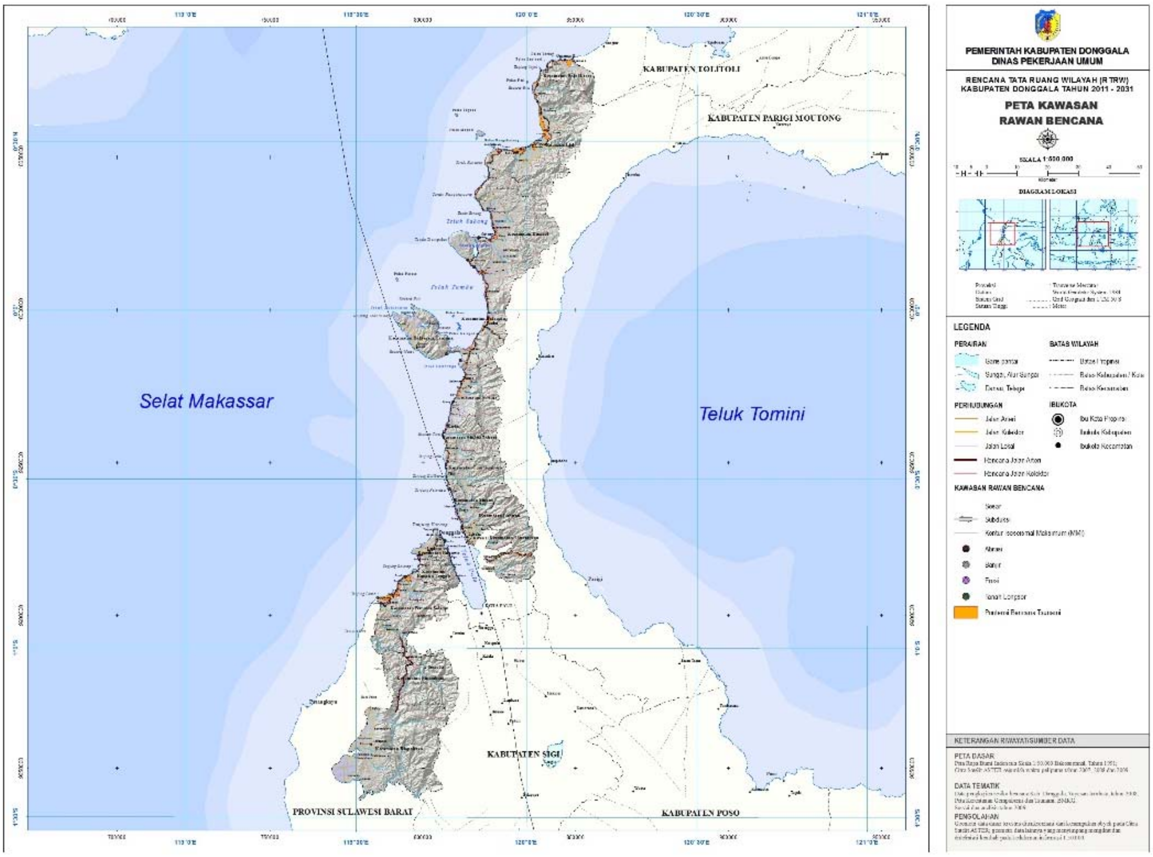
Source: Rencana Tata Ruang Wilayah Kabupaten Sigi 2018-2038 (Draft)

Figure 2-9 Flood Hazard Map (Sigi Regency Draft RTRW 2018-2038)

(4) Donggala Regency RTRW 2011-2031

- Landslide: It has been specified that most areas in Donggala Regency have steep slopes and soft ground. Specifically, the sub-districts of Sojol Utara, Sojol, Damsol, Balaesang Tanjung, Sindue, Labuan, Tanantovea, Banawa and Pinembani are designated as landside-prone areas.
- Flood: It was described that the mechanism of flood is closely related to the pattern of land use and management of the hinterland in the rainy season. Therefore, in spatial planning, conservation and management of the basin and the optimization of the functions of the water catchment are presented. The sub-districts of Sojol Utara, Sojol, Damsol, Balaesang, Balaesang Tanjung, Sirenja, Sindue Tobata, Sindue Tombusabora, Sindue, Labuan, Tanantovea, Banawa, Banawa Tengah, Banawa Selatan, Rio Pakava and Pinembani are specified as flood-prone areas.
- Land Erosion: A risk of the coastal area being eroded by tsunami or large waves has been mentioned in the RTRW. Furthermore, countermeasures to these have been specified

such as (1) restricting activities in flat areas where there is risk of large waves, and in urban and rural areas close to the coast; and (2) build a breakwater as a structural measure. The sub-districts of Banawa, Banawa Tengah, Banawa Selatan, Tanantovea, Labuan, Sindue, Sindue Tobata, Sindue Tombusabora, Sirenja, Balaesang, Balaesang Tanjung, Damsol, Sojol and Sojol Utara are designated as land erosion-prone areas. Additionally, a risk of land erosion along rivers has been mentioned, as well as the occurrence of coast erosion.



Source: Donggala Regency RTRW 2011-2031

Figure 2-10 Disaster-Prone Area Map (Donggala Regency RTRW 2011-2031)

2-2-2 Land Use and Infrastructure Development Policy

(1) Central Sulawesi RTRW 2013-2033

1) Land Use Pattern and Infrastructure Development Plan

Most areas of Palu City, the area along the Palu River in Sigi Regency, and the coastal areas of Palu and Donggala are designated as settlement areas in Figure 2-11. According to the strategic area map in Figure 2-12, the coastal area of Palu is identified as a strategic area for integrated economic development; Palu and its surrounding areas are categorized as urban development area; and Pantoloan area is specified as special economic zone.