行政法人 國家災害防救科技中心
National Science and Technology Center for Disaster Reduction

The 7th South China Sea Tsunami Workshop, SCSTW-7

Application of Tsunami Inundation Potential Maps on Evacuation Planning for Local Governments

Bing-Ru Wu*, Siao-Syun Ke*, Kun-Sung Liu**

* National Science and Technology Center for Disaster Reduction, New Taipei City, Taiwan

** Department of Civil Engineering, Kao Yuan University, Kaohsiung City, Taiwan

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Outline

- Background and Objectives
- Tsunami Inundation Potential Maps in Taiwan
- Guideline of Tsunami Evacuation Planning Using Tsunami Potential Maps
- An Example of Practical Application: Hualien City
- Conclusion

Lesson learned from recent tsunami disasters

2012/10/27 Canada offshore earthquake M_w7.7	Exceeding 100 thousands of people were evacuated in Hawaii and caused serious traffic jam.

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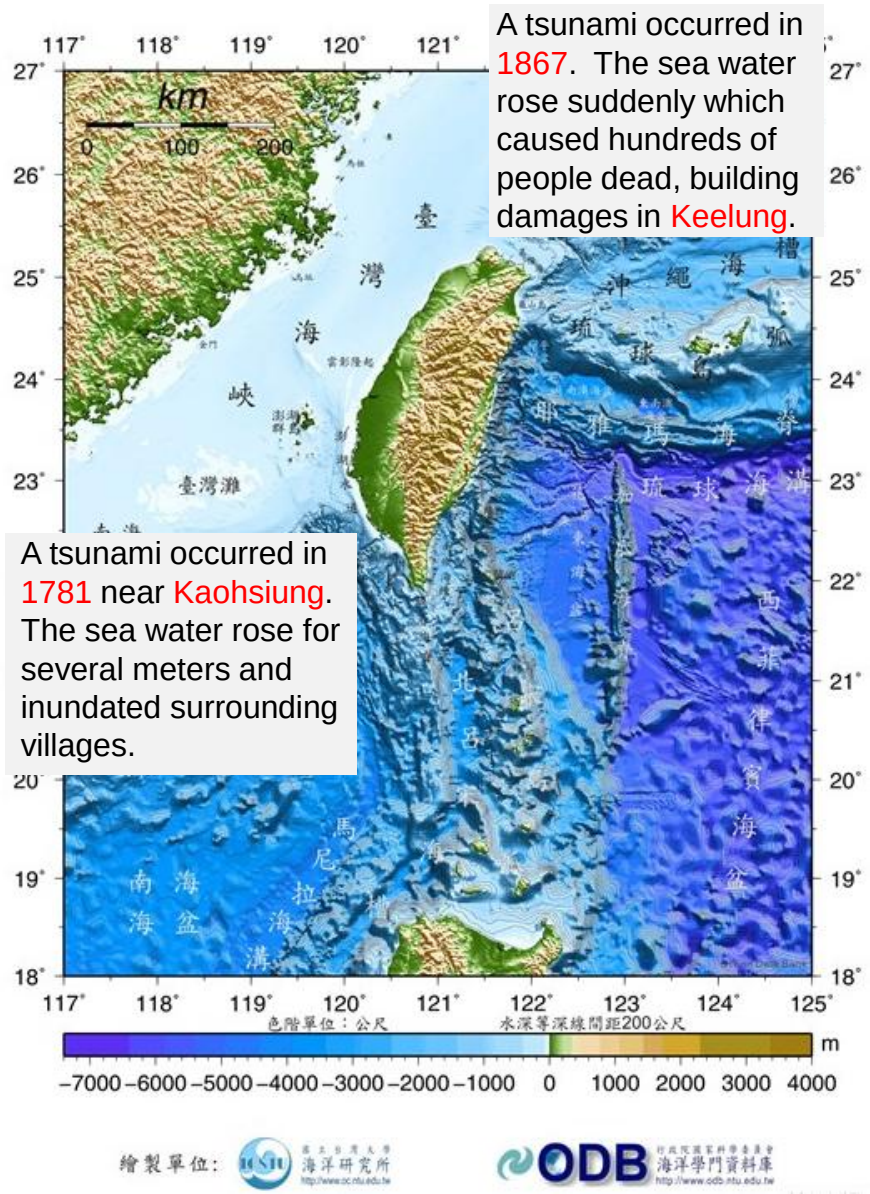
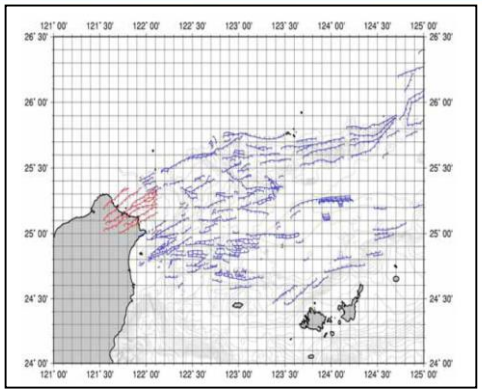
2011/03/11 Tohoku earthquake M_w9.0	compound disasters, 18,537 death and missing, 290 thousands of people evacuated, malfunction of local governments.

2010/02/27 Chile offshore earthquake M_w8.8	More than 1,200 death, serious damages of infrastructures

2004/12/26 Sumatra earthquake M_w9.3	Exceeding 290 thousand death surrounding the India Ocean

Potential Tsunami Threat Surrounding Taiwan





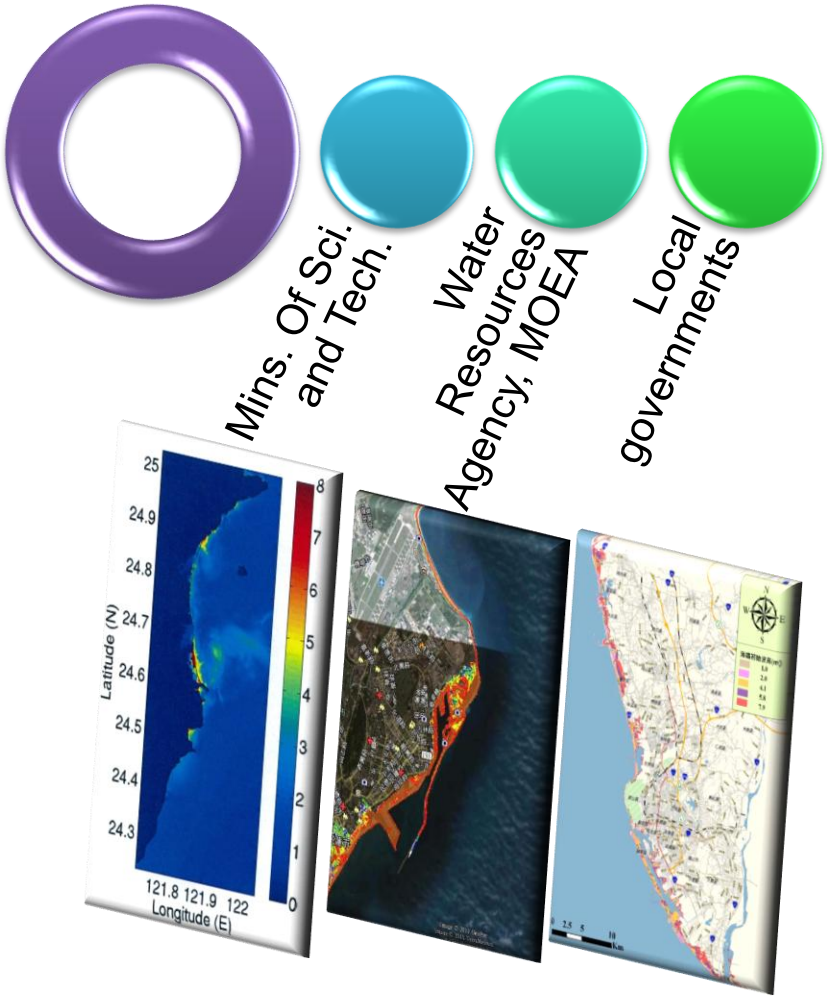
Distribution of ocean-bottom faults in the north-eastern offshore Taiwan

- **In the north-eastern offshore Taiwan**
  - If a tsunami induced by an earthquake in this area, the arrival time will be just several tens of minutes.
- **In the south-eastern of Taiwan**
  - If a significant tsunami generated in the Manila Trench, it may have serious influence to the south-eastern of Taiwan because of plain tomography in that area.

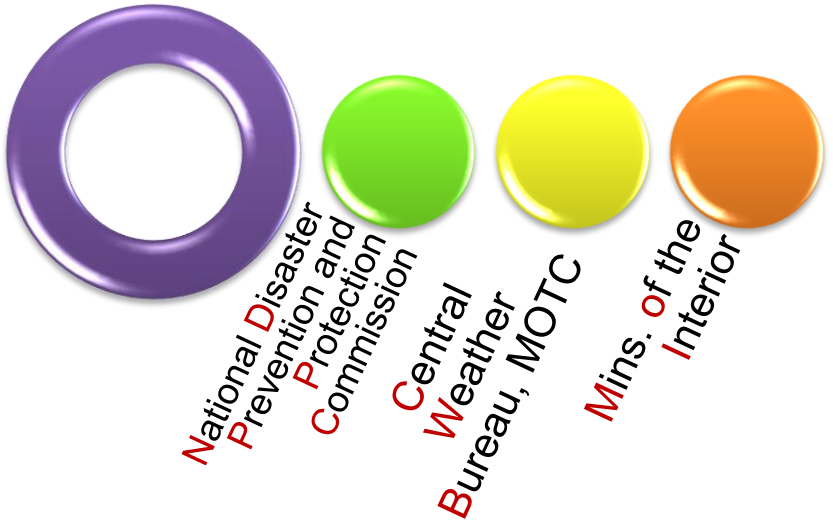
If a major tsunami generated surrounding Taiwan, the operation of evacuation will be challenging because of short leading time.

Researches and Policy Measures for Tsunami in Taiwan

Tsunami simulations



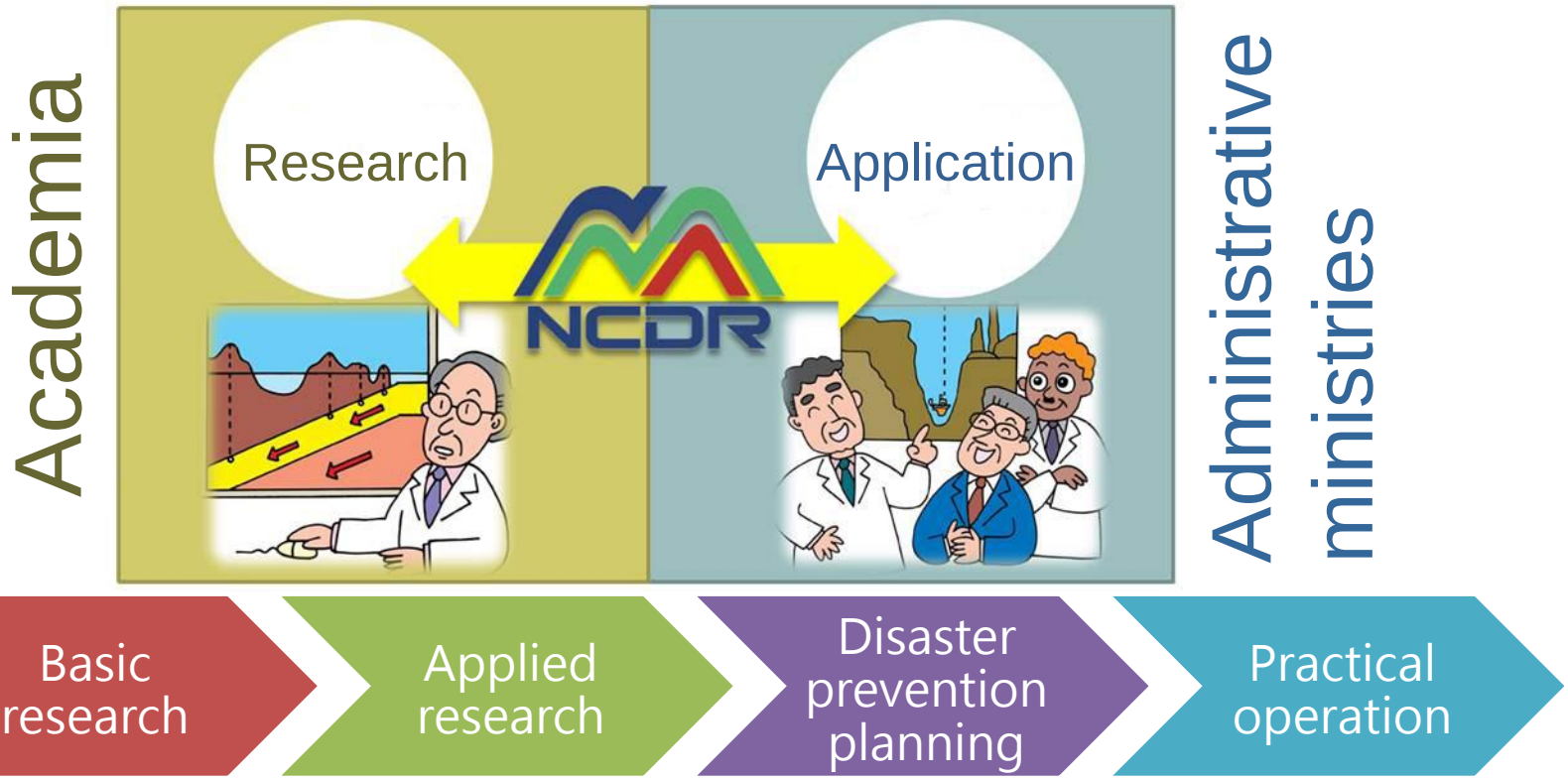
Policy principles, regulations, disaster prevention plans



- ✓ Policy principles of improving the tsunami disaster prevention for local governments (NDPPC, 2005)
- ✓ Operation principles of issuing tsunami information, (CWB, 2011)
- ✓ Standard operation processes of issuing tsunami alarm using the air-raid alarm system, (MOI, 2011)
- ✓ Tsunami disaster prevention measures in the earthquake disaster prevention plan, (modified by MOI, 2012)

Issues Remained to be Solved

- There are some gaps between **scientific research results** and application on **disaster prevention planning**
- Many local governments lacked for **tsunami potential data** to organize the disaster prevention plan



Purpose and Application of Tsunami-Evacuation Guideline

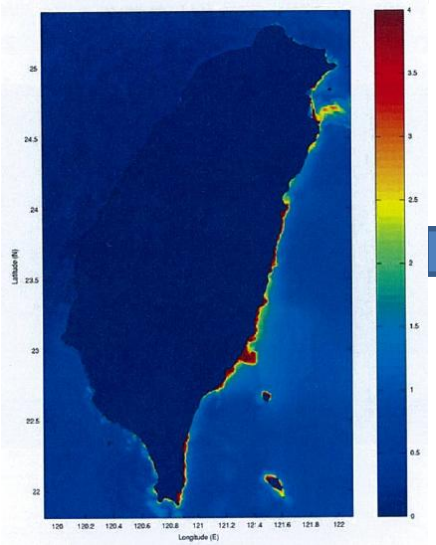
NCDR played the key role of promoting research results to disaster-prevention practice

Research projects funded by central and local governments

Produce tsunami inundation potential maps and organize a guideline for the planning of tsunami evacuation (NCDR)

Local governments produce evacuation maps and open to the public

Tsunami Inundation Simulation (Central and local governments)



Tsunami Inundation Potential Map (Central and local governments)

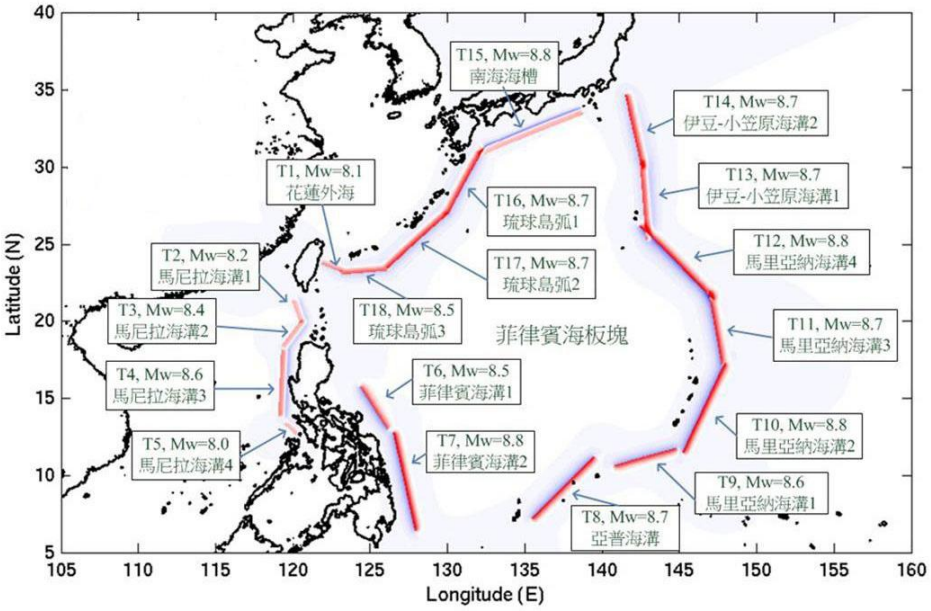
Tsunami Evacuation Plan (Local governments)

- Allocate tsunami warning area
- Analysis of population influenced by tsunami
- Planning of evacuation route
- Shelter planning
- Planning of evacuation building and highland

Evacuation Map (Local governments)

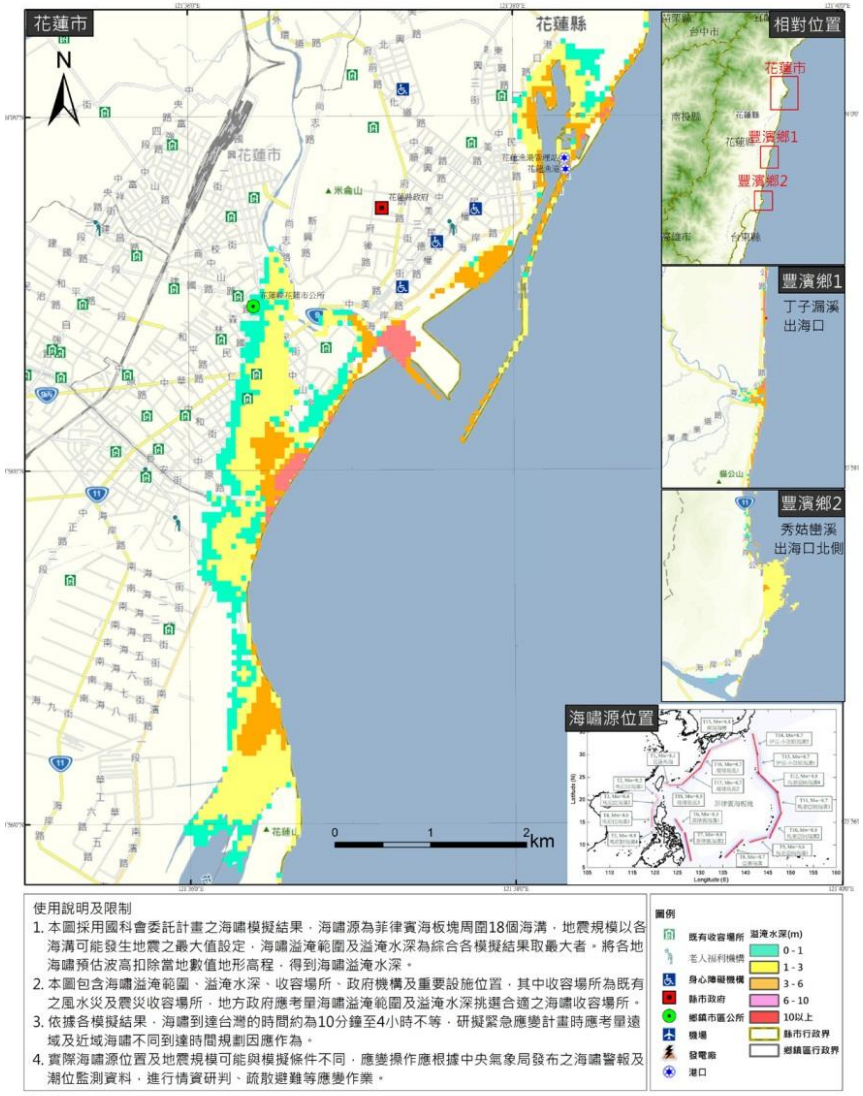
Tsunami Potential Maps

- **From the 18 tsunami simulation cases (Wu, 2011), the extent and depth of inundation can be obtained by subtracting the elevation onsite from the estimated tsunami wave height.**
- **Take the maximum value of inundation depth to plot the tsunami potential maps.**



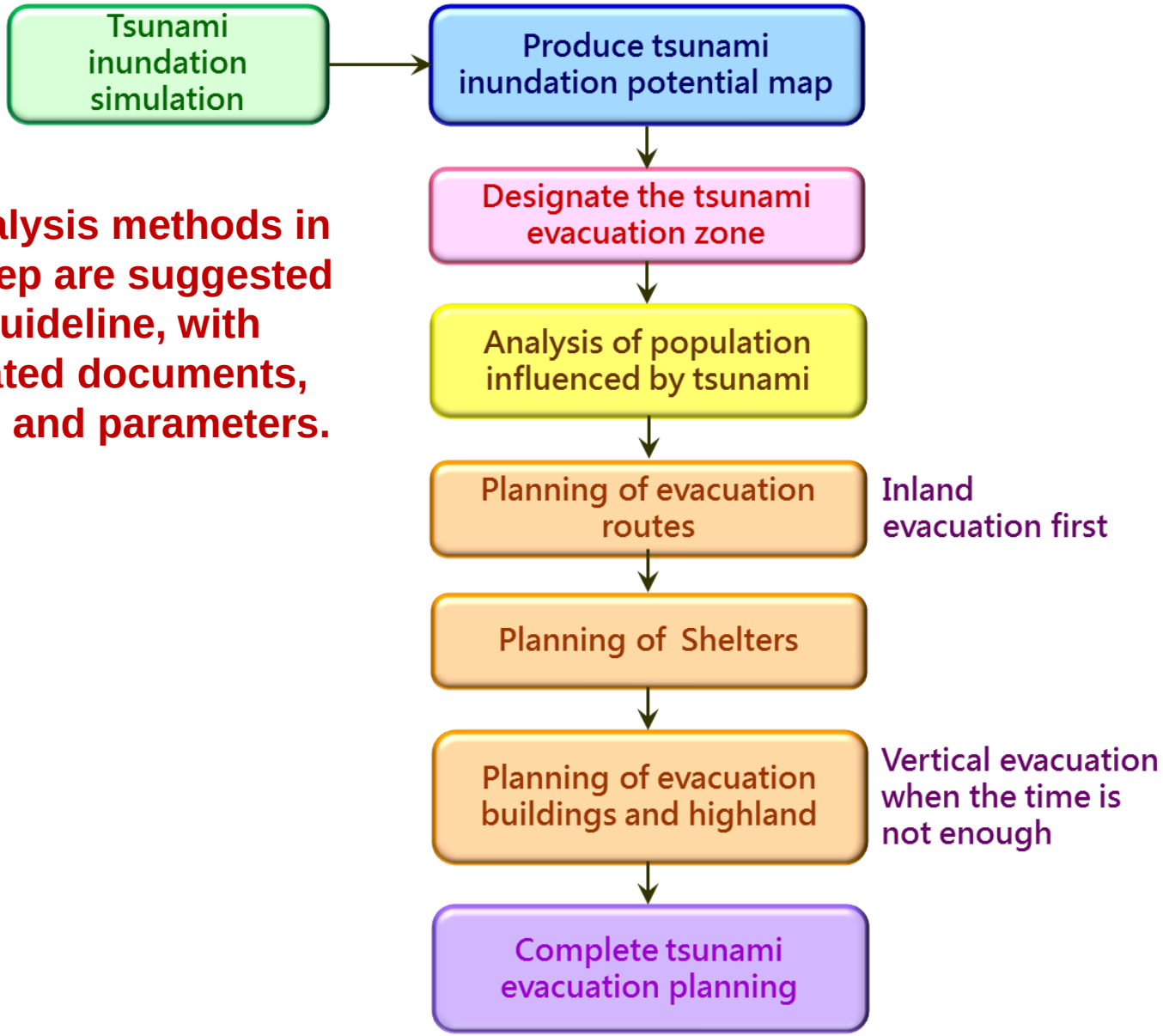
Tsunami sources and earthquake magnitudes

Tsunami Potential Map in Hualien City

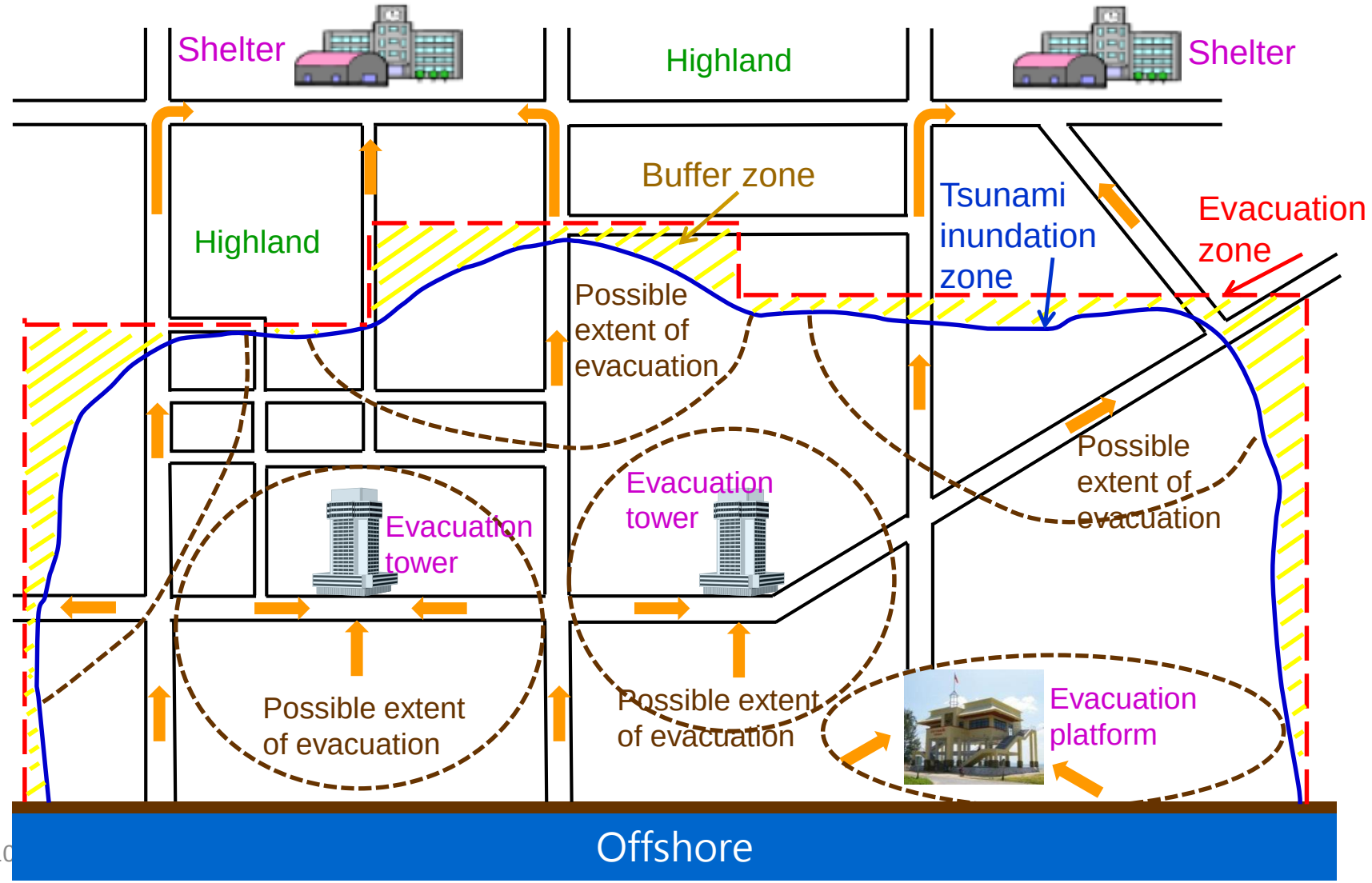


Applying tsunami inundation potential maps in evacuation planning

The analysis methods in each step are suggested in the guideline, with associated documents, criteria, and parameters.



Concepts of Tsunami Evacuation Planning



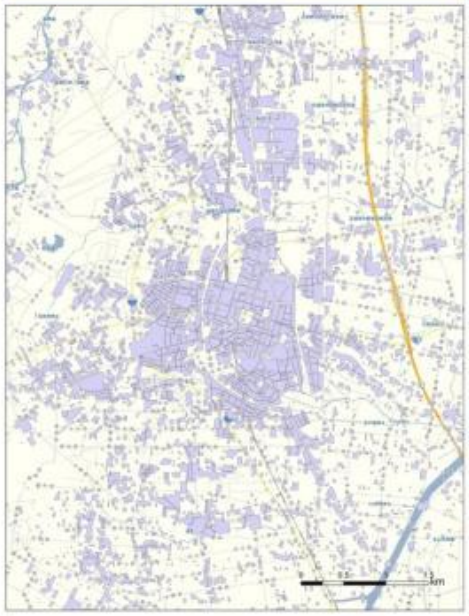
Analysis of Population Influenced by Tsunami

Three processing methods were suggested for local governments

Method 3 Gridded analysis of population influenced by tsunami

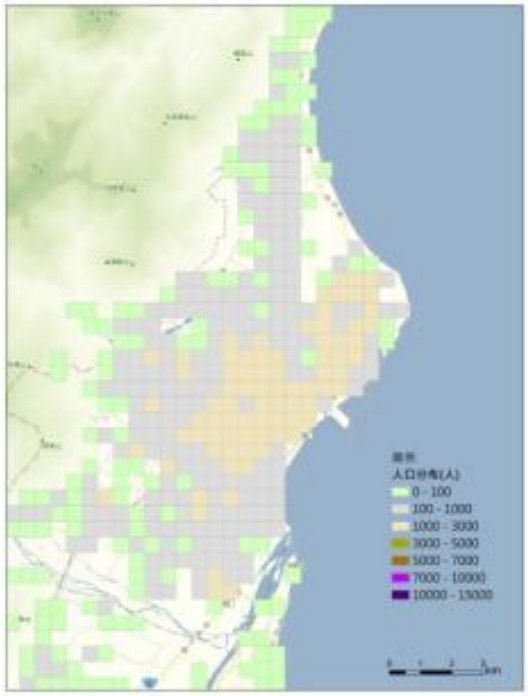
1. Calculate the areas of building base in each grid and sum them all.
2. Assume the population is distributed over existed buildings. Calculate the ratio population/building-base-area.

Distribution of buildings



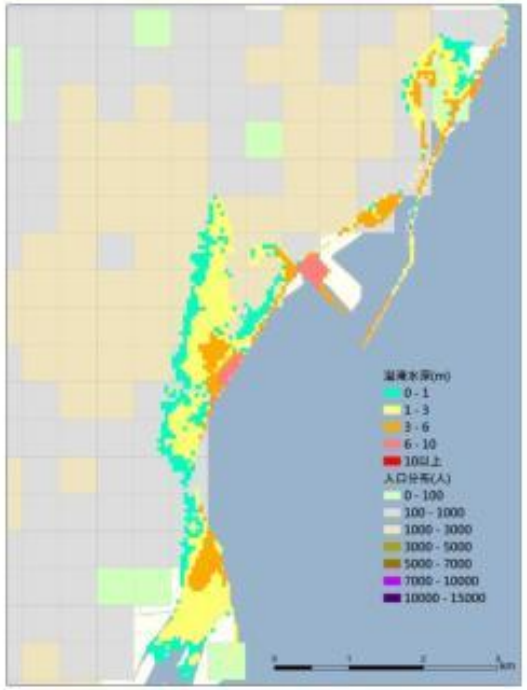
3. Multiply the ratio population/building-base-area by the building-base area in a grid to obtain the population in a grid.

Gridded population distribution



4. Assembly the tsunami potential map and the gridded population map to calculate the influenced population.

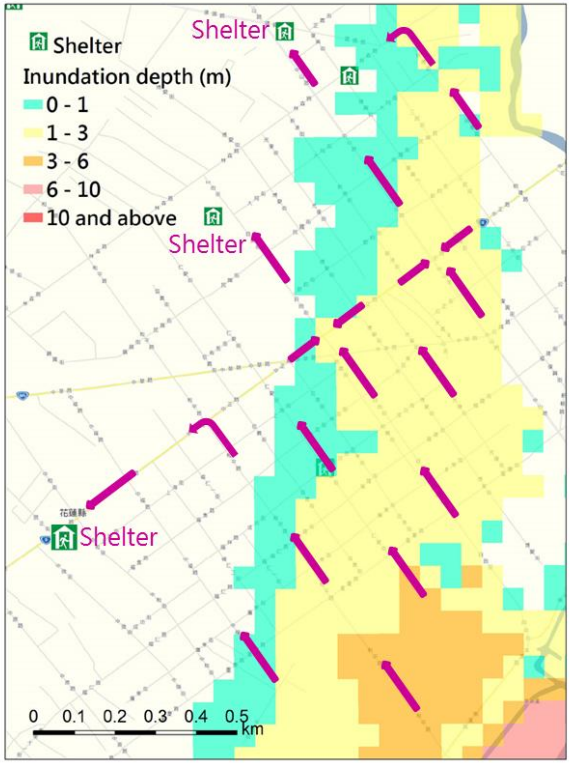
Population influenced by tsunami



Planning of Evacuation Route

1. Assemble the tsunami potential map and street map. Select possible routes to leave the inundation zone.

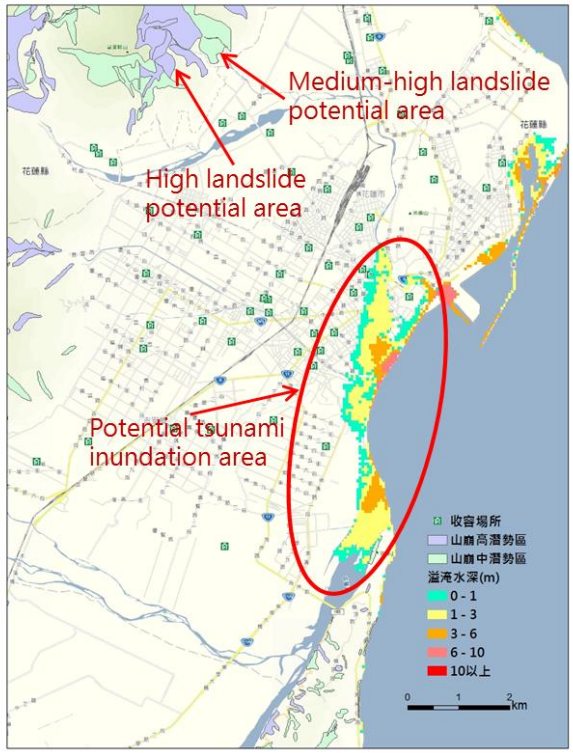
Planning of evacuation route



2. The evacuation direction away from the coast and toward highland is preferred.

3. The evacuation route with high landslide susceptibility should be avoided.

Planning of evacuation route considering landslide susceptibility



4. Select the shortest evacuation route. The distance should not exceed the possible walking distance*.

5. If the evacuation routes pass bridges, the seismic resistant capacity of the bridge should be evaluated.

6. After field inspection, the evacuation route can be designated by local governments. The guiding board should be installed.

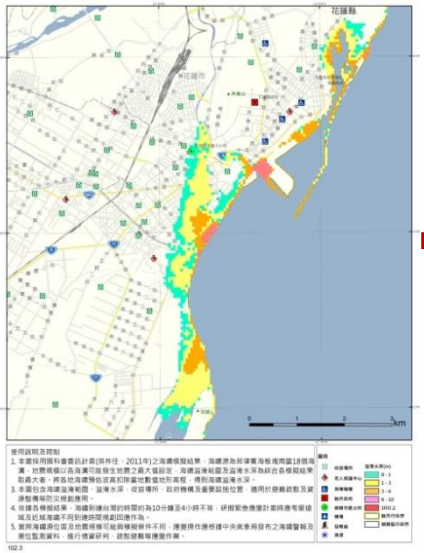
*Possible walking distance
=Walking speed × (tsunami arrival time – preparation time)
(less than 1km was recommended)

- ✓ Walking speed:
  0.8-1.3m/sec for elders and crowds
  0.5m/sec for disabled people, infant
- ✓ Preparation time: about 5 to 10 minutes

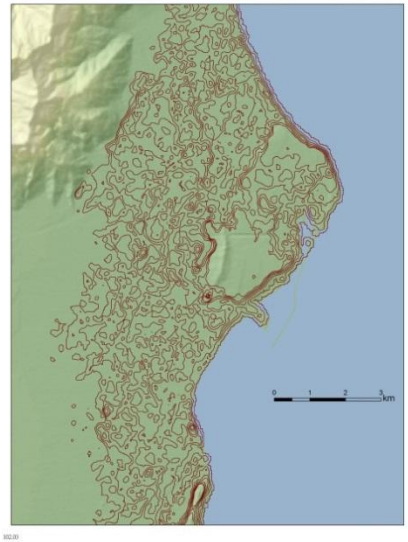
Planning of Shelters

1. Select several shelters outside the inundation zone
2. Select the shelters at higher land
3. Eliminate the shelter with high landslide susceptibility
4. Select the shelters with reasonable walking distances

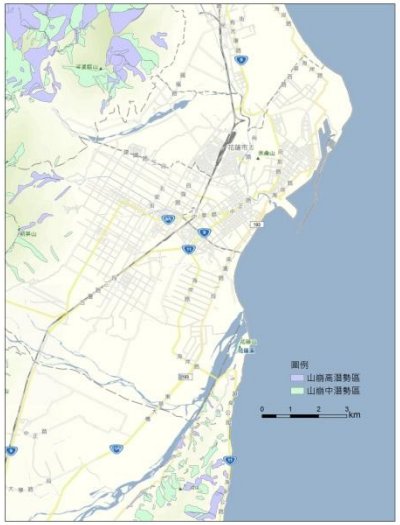
Tsunami potential map



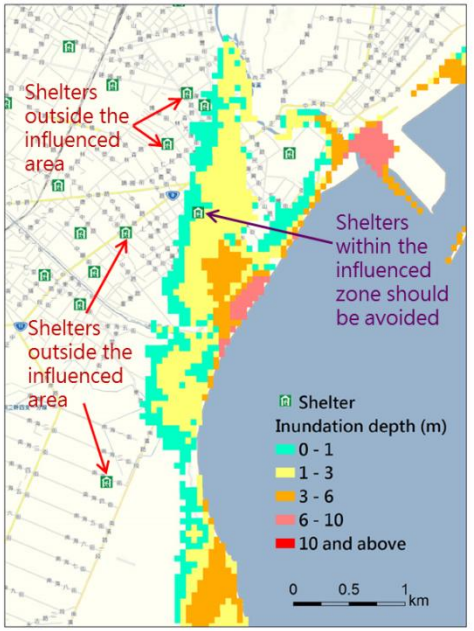
Digital tomography model



Landslide susceptibility map



Planning of shelters



Planning of Evacuation Buildings, Highland, and Towers

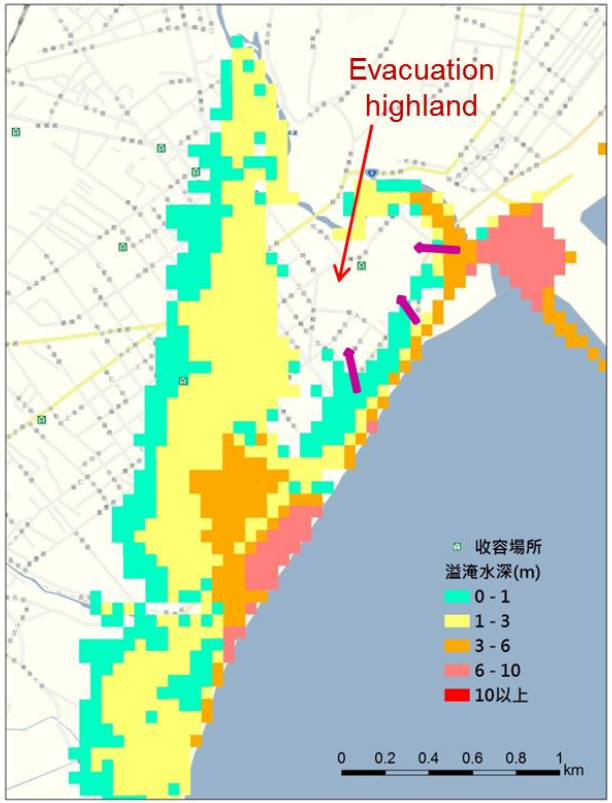
Evacuation building

1. Select several possible tall buildings regarding the inundation depth
2. Select the proper building by considering the safety and function criteria
3. Detailed assessment of tsunami-resistant capacity is recommended

Evacuation highland

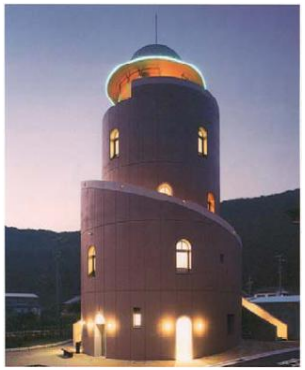
Highland at elevation higher that 10m is recommended

Planning of evacuation highland



Evacuation tower

Some evacuation towers or platforms may be constructed in costal area



Example: Nishiki tower

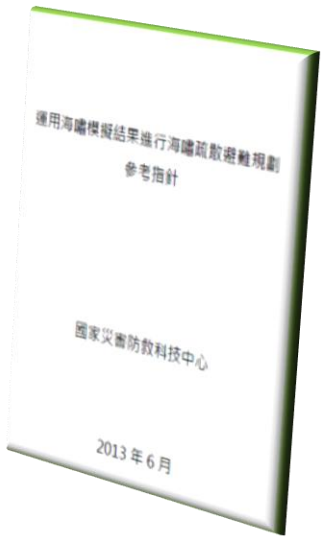
Example: Tasukaru tower

An Example of Practical Application: Hualien City

- The shelter inside the tsunami inundation area was eliminated from the list.
- Some major roads were designated as the evacuation route.
- The Huagang mountain was selected as the evacuation highland.
- The location of government agencies and welfare institutions were labeled in the map for references of planning.

Conclusions

- The tsunami inundation potential maps of 15 city/county in Taiwan have been produced
  - A website was established for querying and downloading those maps
- A guideline of organizing the tsunami evacuation plan was completed and submitted to the government agencies
  - The Department of the Interior asked local governments to complete the tsunami evacuation planning by 2013
- Some associated measures for governments and citizen were also included in the guideline.
  - The issuing and transmitting of tsunami alarm, guiding and assisting for evacuation, education training and drills



Workshops for local governments

Website: http://satis.ncdr.nat.gov.tw/Dmap/