

# Ishinomaki Tsunami Intensity Mapping (ITIS<sub>2012</sub>) for the Tohoku Event, March 11 2011, Japan

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**National and Kapodistrian  
University of Athens**

## Objectives:

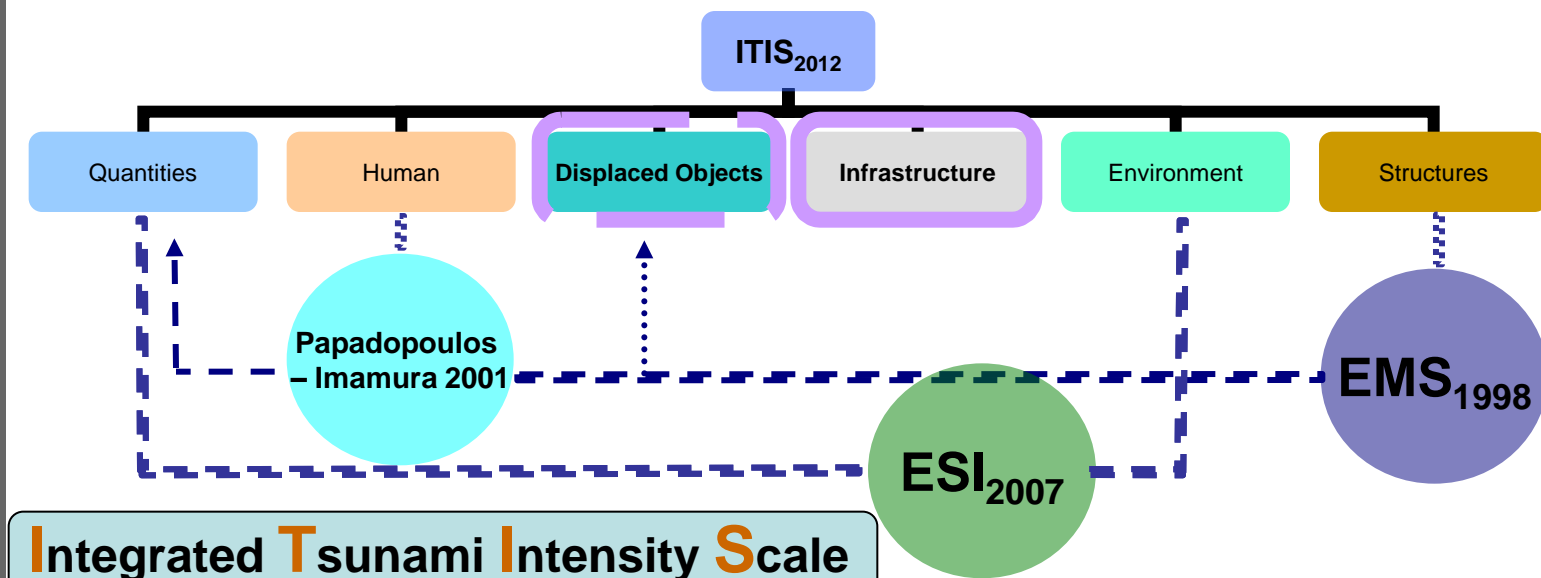
mapping (ITIS<sub>2012</sub>) a recent and mega-event, which is combining:

- large amount of available data
- wide range of damages
- a variety of damage quality & quantity characteristics



Conclusions on:

- the tsunami vulnerability of the study area
- the applicability and the perspectives of the scale



[E. Lekkas et al., 2012]

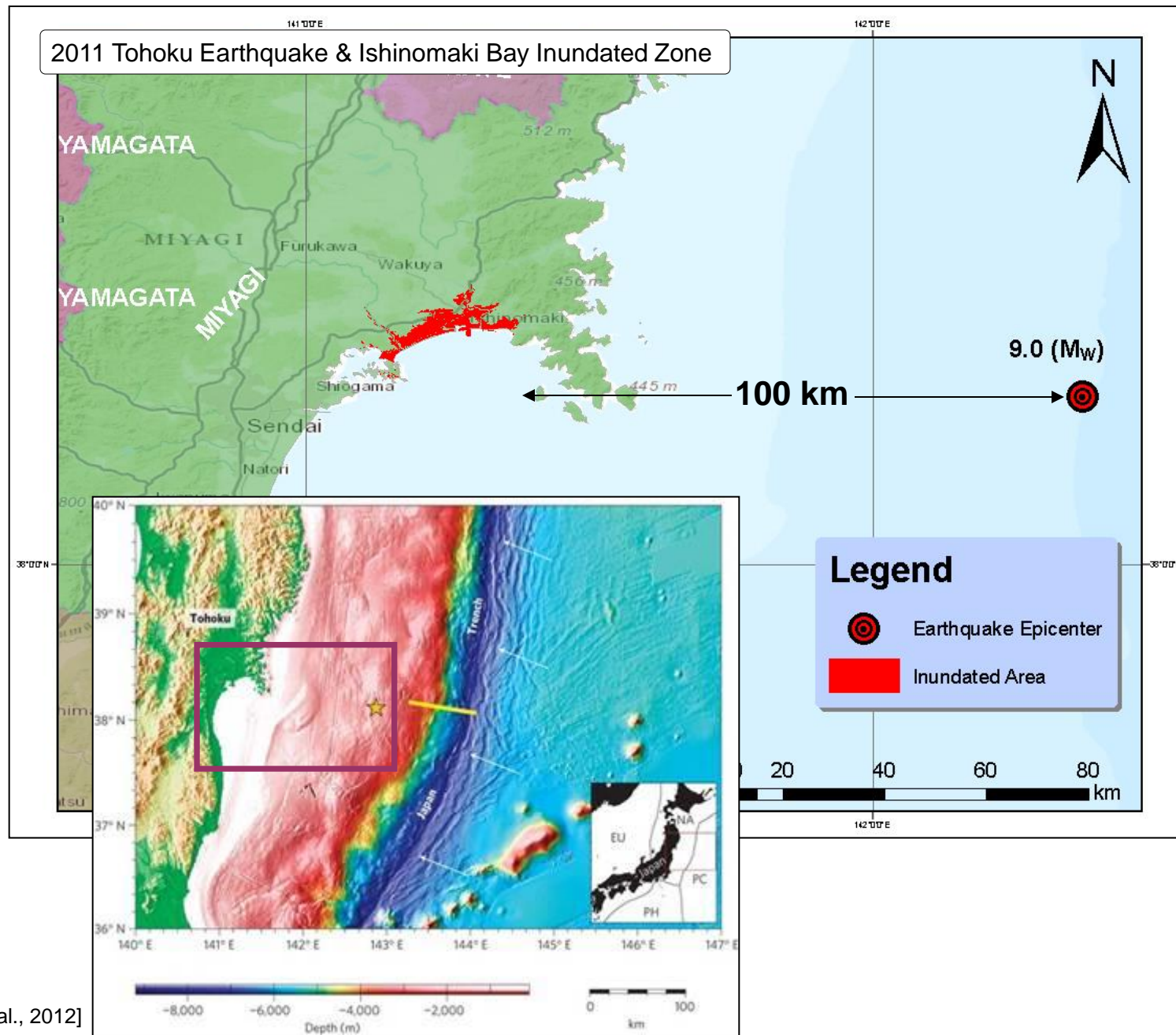
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XII

1 Quantities	Impact on				
	2 Human	3 Objects	4 Infrastructure	5 Environment	6 Structures
<ul style="list-style-type: none"> <li>• wave height</li> <li>• run-up</li> <li>• inundation distance</li> <li>• inundation area</li> </ul>	<ul style="list-style-type: none"> <li>• perception</li> <li>• reaction</li> <li>• losses</li> </ul>	<ul style="list-style-type: none"> <li>• vessels</li> <li>• means of transport</li> <li>• heavy objects</li> <li>• fires (due to displacement)</li> </ul>	<ul style="list-style-type: none"> <li>• port facilities</li> <li>• industry facilities</li> <li>• lifelines</li> </ul>	<ul style="list-style-type: none"> <li>• erosion/ shoreline changes</li> <li>• deposits</li> <li>• trees &amp; bushes</li> <li>• boulders</li> <li>• debris</li> <li>• pollution</li> <li>• in situ fires</li> </ul>	Based on: <ul style="list-style-type: none"> <li>• structural material</li> <li>• damage grade</li> <li>• spatial density of the above criteria</li> </ul>

complementary

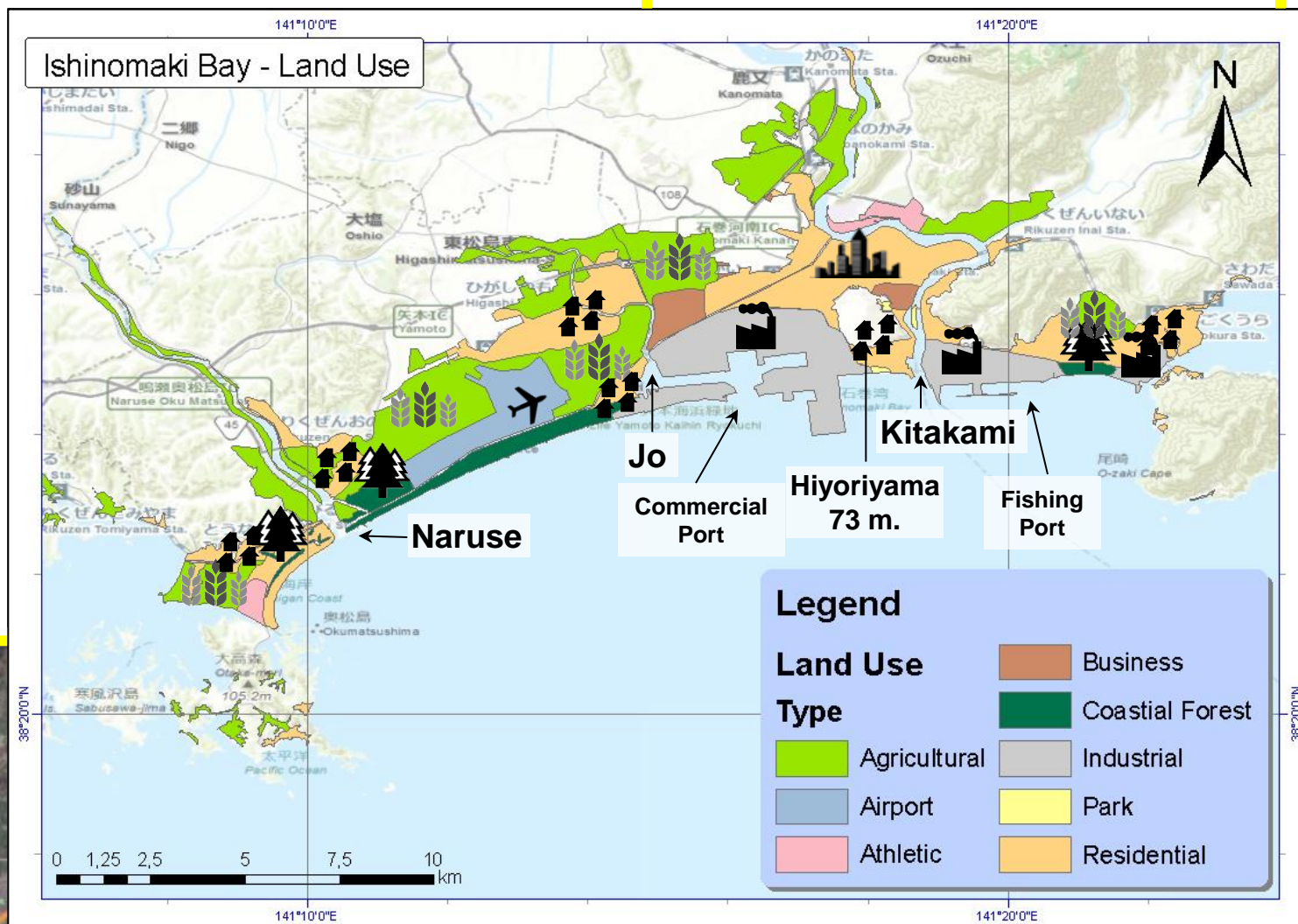
1. Quantities
  2. Human
  3. Objects
  4. Infrastructure
  5. Environment
  6. Structures
- Results
- Conclusions

# Tohoku EQ | Study Area





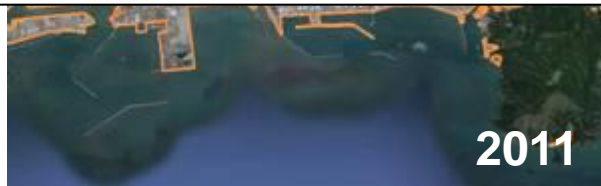
## Tohoku EQ | Study Area



## Local economy:

- fishing
- fishing products' industry
- rice production

Attached to "Hazard Map of Ishinomaki"  
[http://www.city.ishinomaki.lg.jp/static/guide\\_ishinomaki/tsunami/](http://www.city.ishinomaki.lg.jp/static/guide_ishinomaki/tsunami/)



2011

[ESRI World Topo Map,  
 Japan Oceanographic Data Center  
 S. Masaru, 2011]

[S. Fraser et al., 2012]

Introduction

Study Area

Methodology

1. Quantities

2. Human

3. Objects

4. Infrastructure

5. Environment

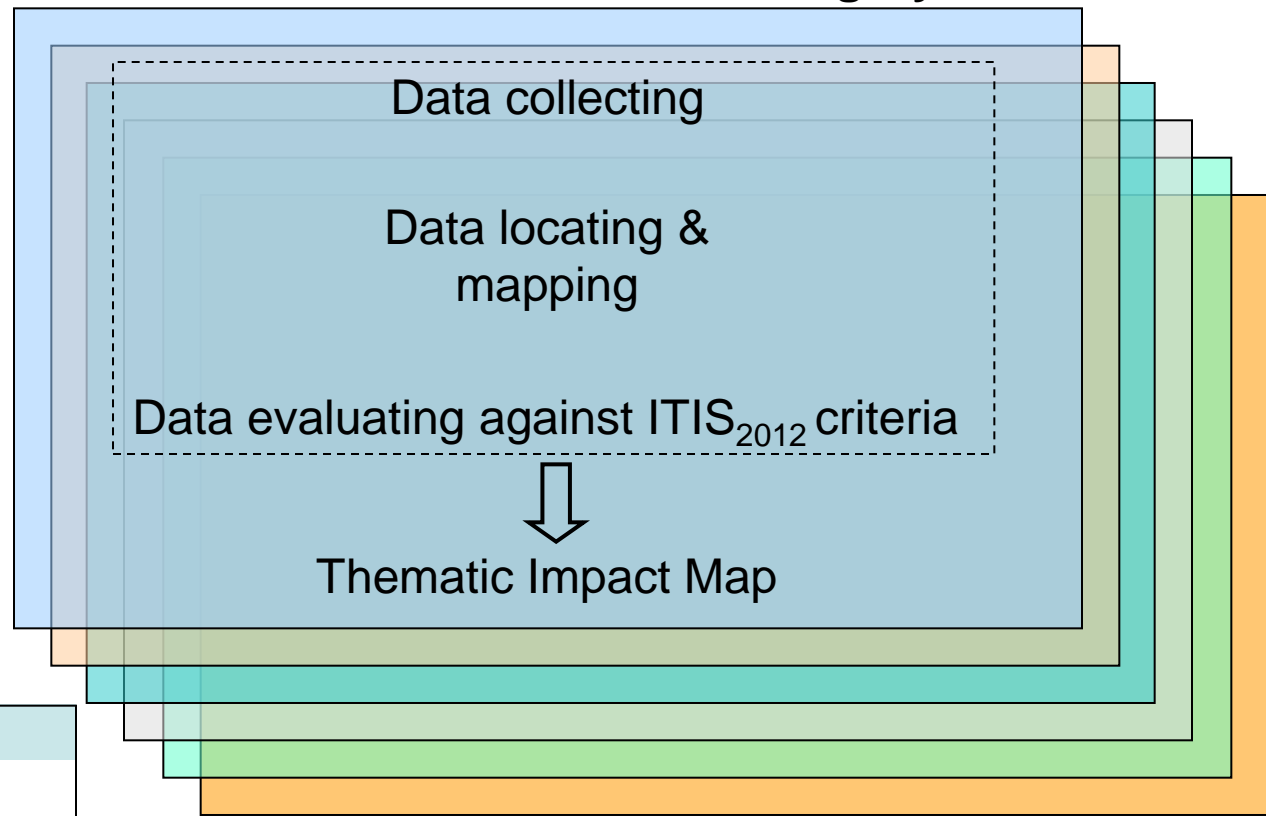
6. Structures

Results

Conclusions

## Methodology

For each criteria category



### Sources:

#### - Primary Data:

- Google Earth
- Google Street View
- Google Memories for the Future
- Air photos

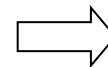
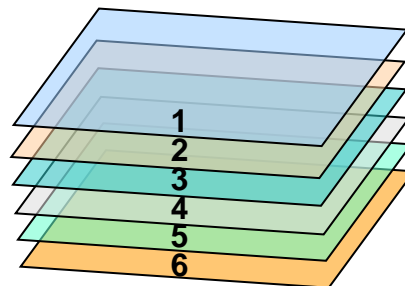
[Geospatial Information Authority of Japan]

#### - Secondary Data:

- Literature
- Authorities' Reports
- Press & Web

#### - Also used:

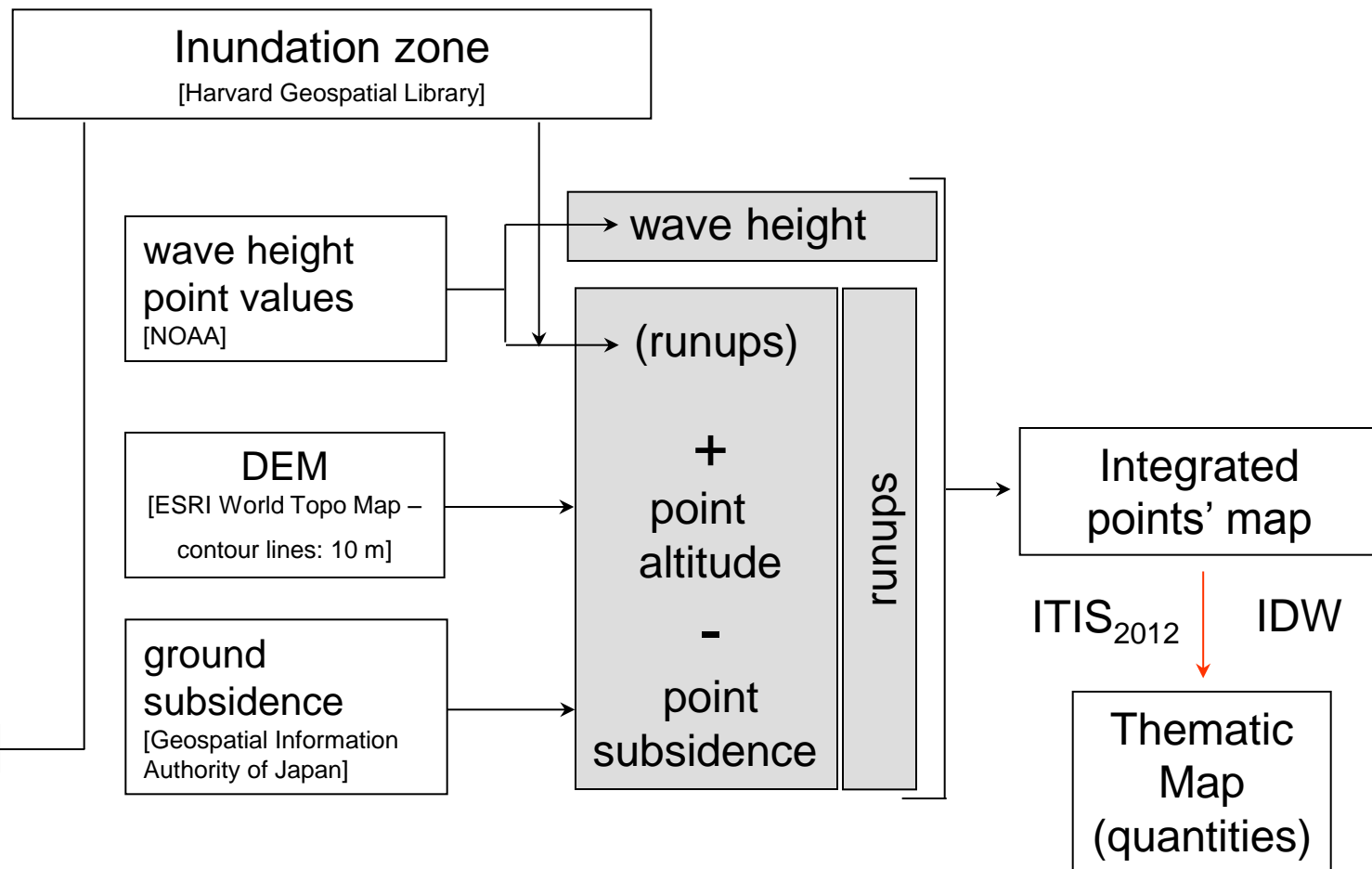
- ESRI ArcMap 9.3, World Topo Map
- Bathymetric data [Japan Oceanographic Data Center]



FINAL INTENSITY  
ZONING MAP

**Criteria:**

- wave height
- run-up
- inundation distance
- inundation area



# Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

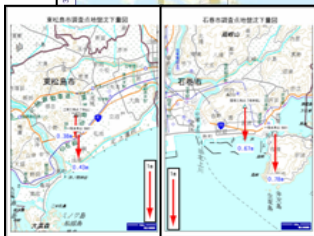
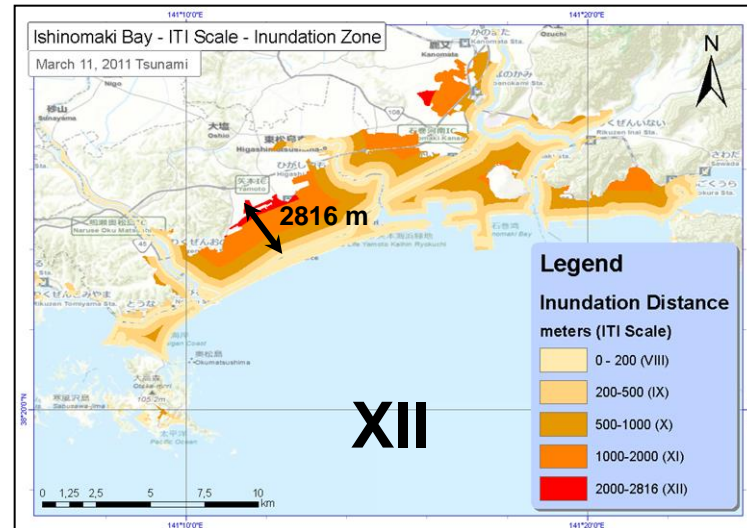
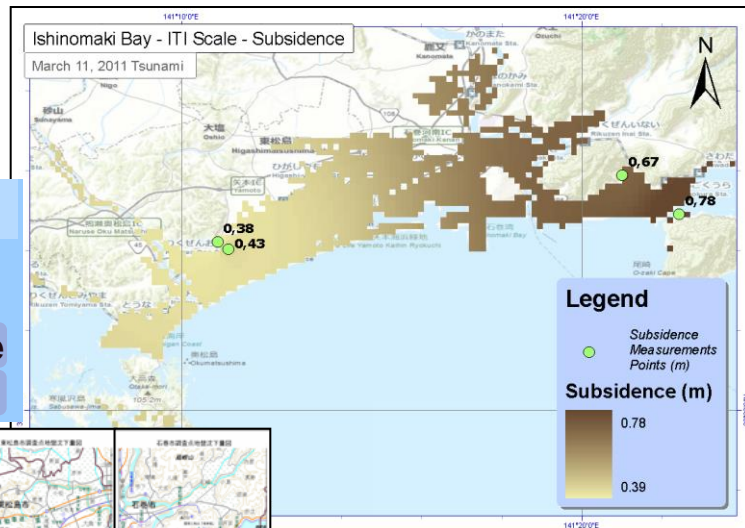
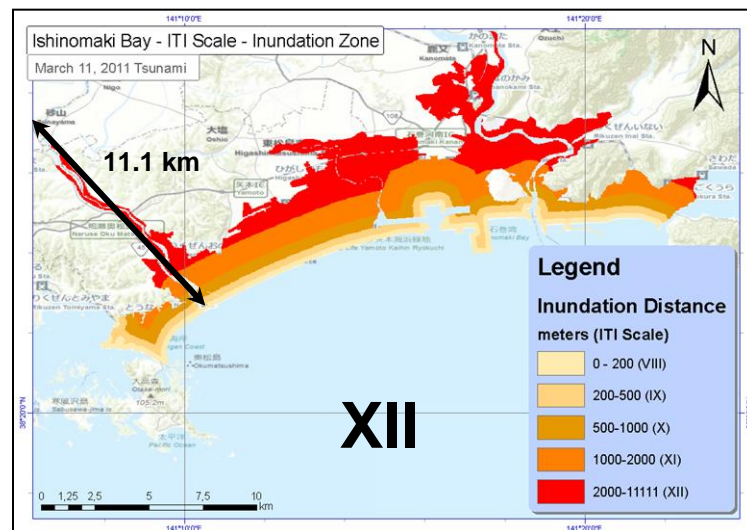
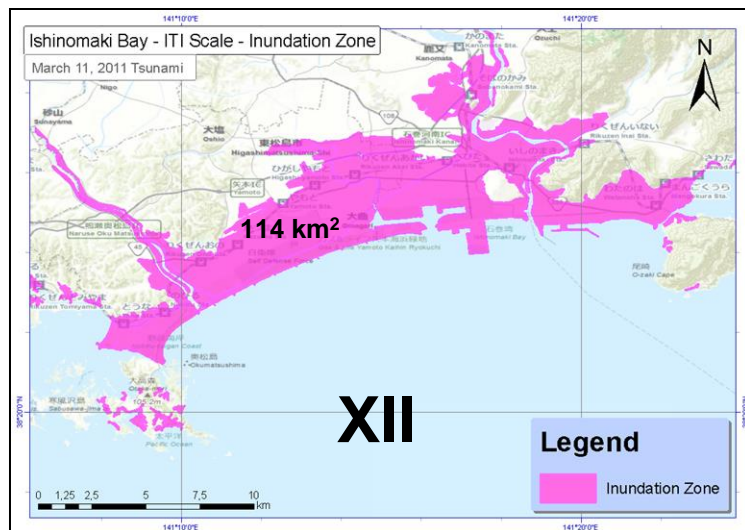
## Results

## Conclusions

### Criteria:

- wave height
- run-up
- **inundation distance**
- **inundation area**

# Methodology | Data | Thematic Map



[Geospatial Information Authority of Japan]



## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

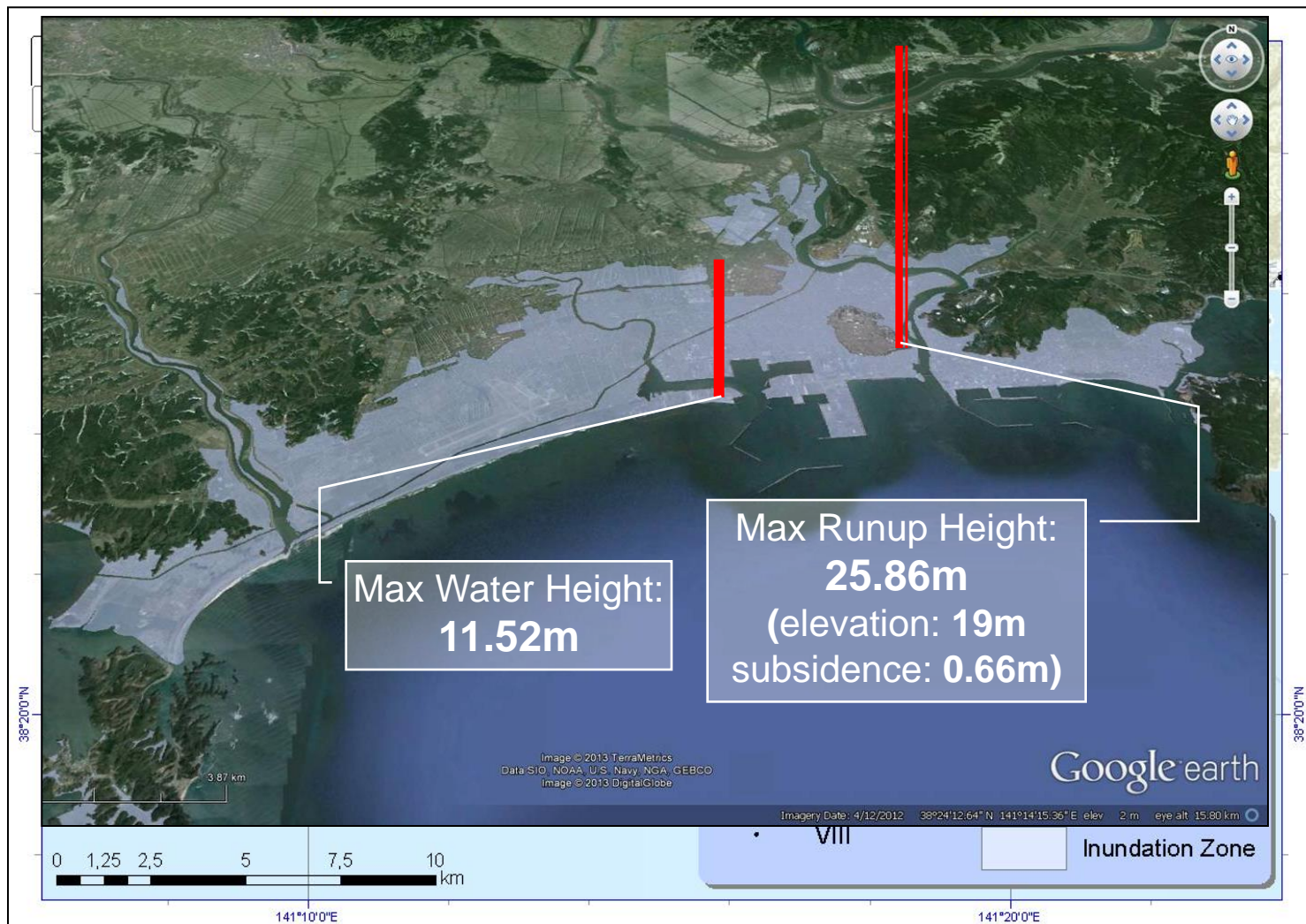
## Results

## Conclusions

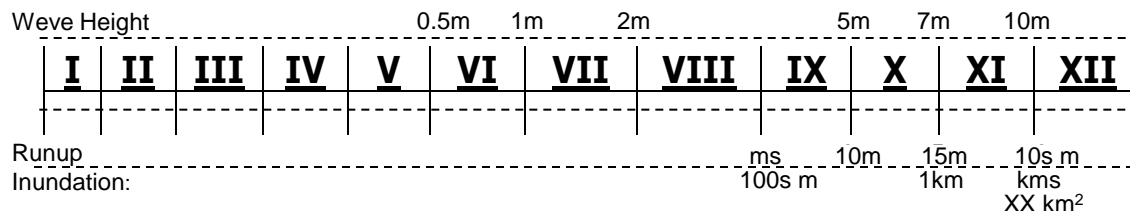
### Criteria:

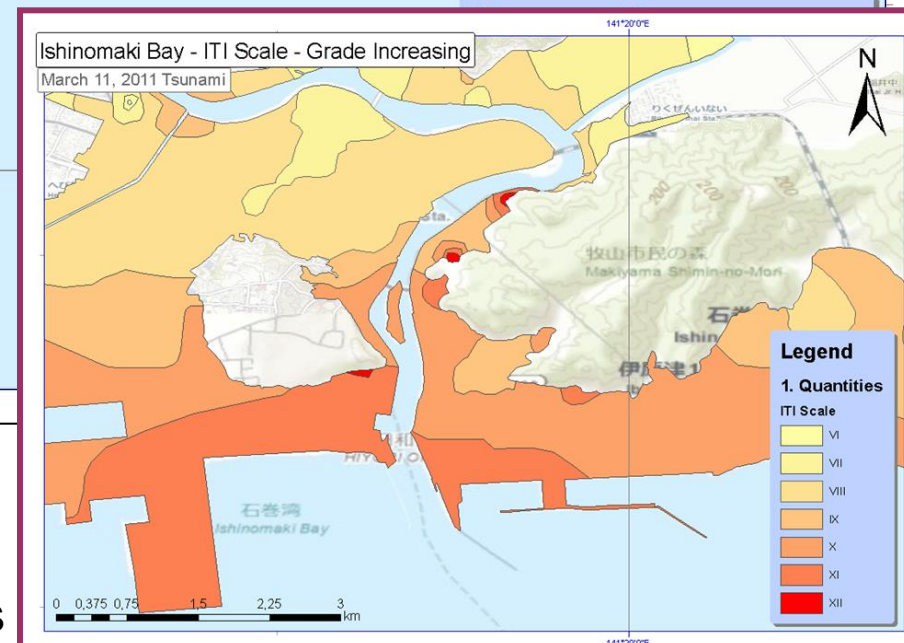
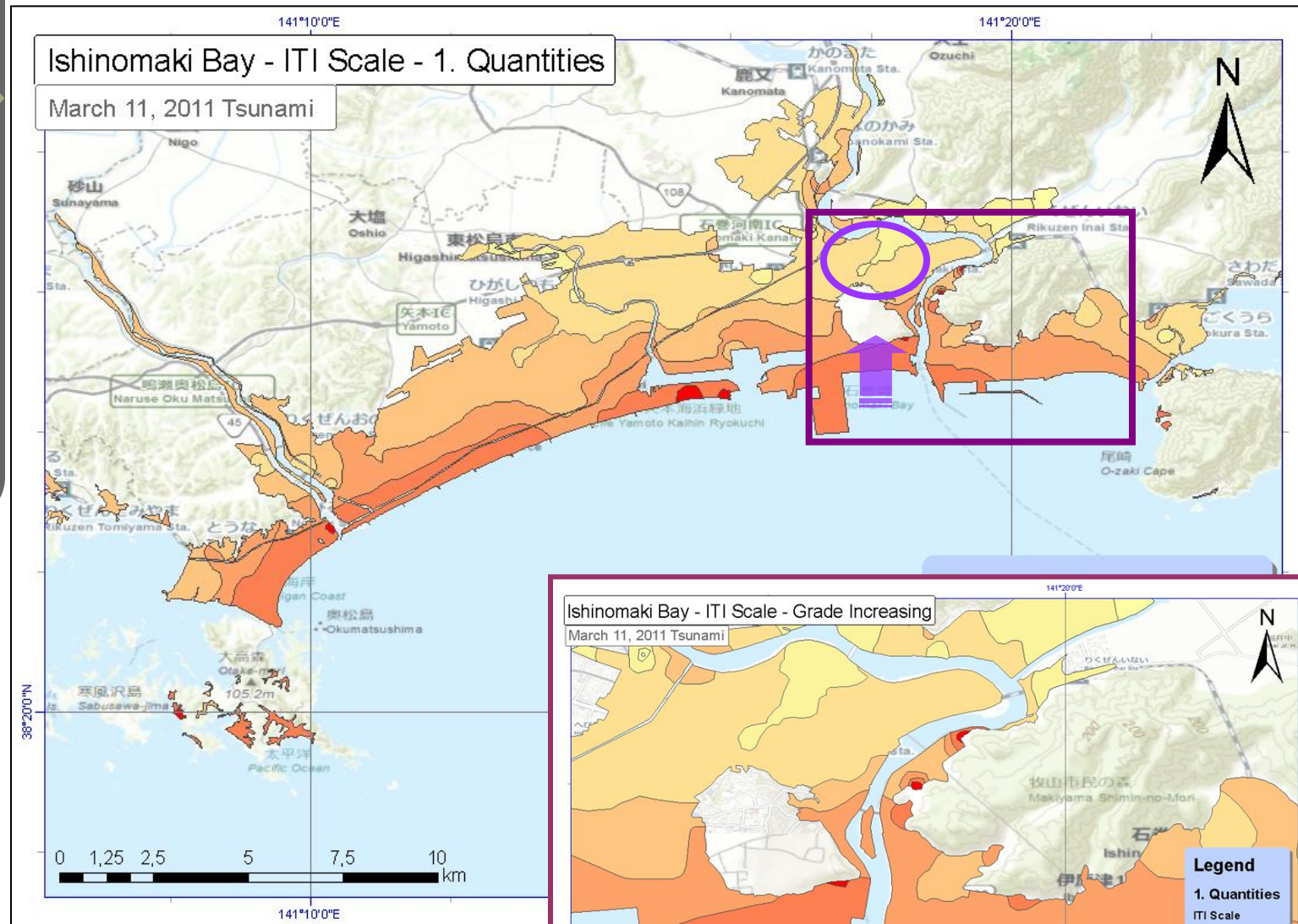
- wave height
- run-up
- inundation distance
- inundation area

# Methodology | Data | Thematic Map



[NOAA, Geospatial Information Authority of Japan, ιδία επεξεργασία]





- Gradual intensity decrease inland (VI – XII)
- Intensity increase locally in steep relief areas



## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

## Results

## Conclusions

## Criteria:

- perception
- reaction
- losses

## Methodology | Data | Thematic Map

### Questionnaire survey to survivors:

[Y. Goto et al., 2012]

underestimation ↓ limited drills participation

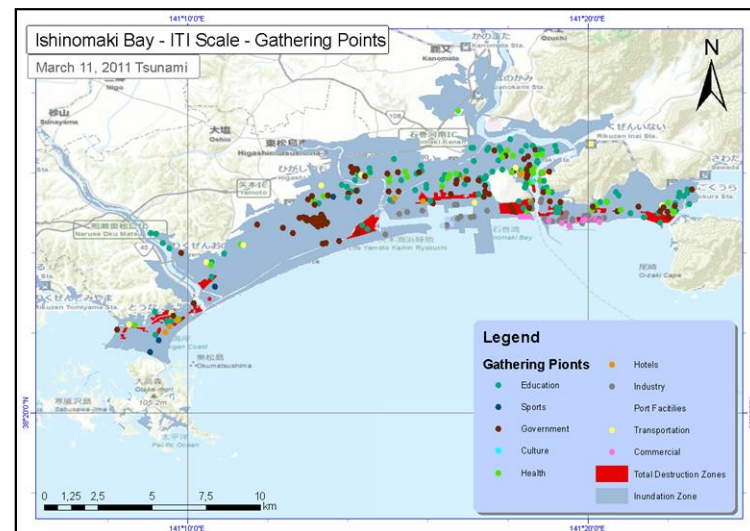
Victims' accumulation in  
residential zones

- population density  
[Census 2005 & Tani Kenji, 2011]
- total destruction zones  
[The Association of Japanese Geographers, 2011]
- population gathering points  
[ESRI World Topo Map]

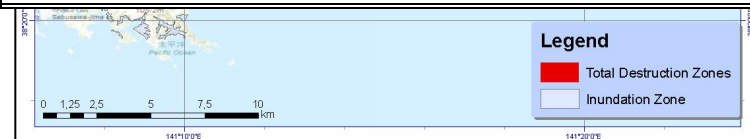
Thematic  
Map  
(human)

confirmation

**Data:**  
victims / municipality  
2 massive-death incidents



Points Category	Weighted Factor
shopping centers - markets	2
schools - nurseries	1-3
governmental buildings	1-2
hotels	1-2
industry & port facilities	2
hospitals - ιατρικά κέντρα	1-2
railway stations	1-2
museums	2
athletic centers	1



[The Statistics Bureau & the Director-General  
for Policy Planning of Japan]

[EERI Special Earthquake Report, Nov 2011]

[DGPR, French Ministry of Ecology, 2013]

## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

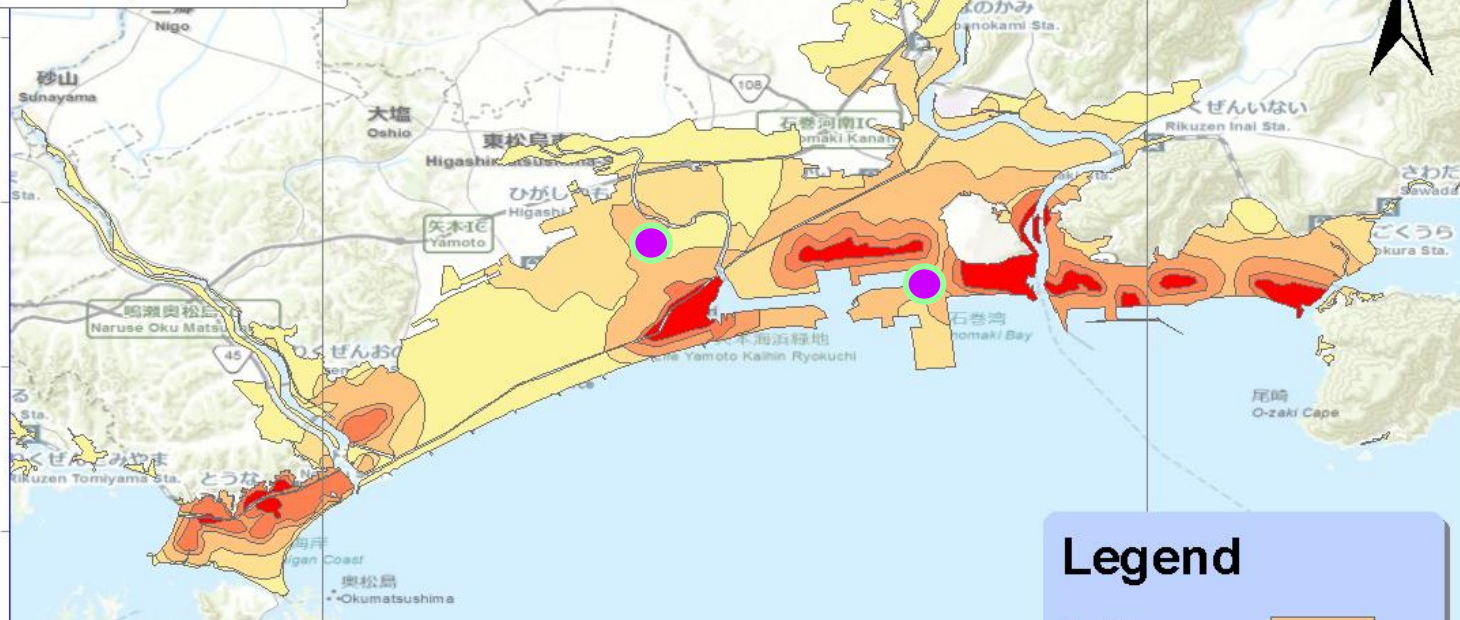
## Results

## Conclusions

# Methodology | Data | Thematic Map

## Ishinomaki Bay - ITI Scale - 2. Human

March 11, 2011 Tsunami



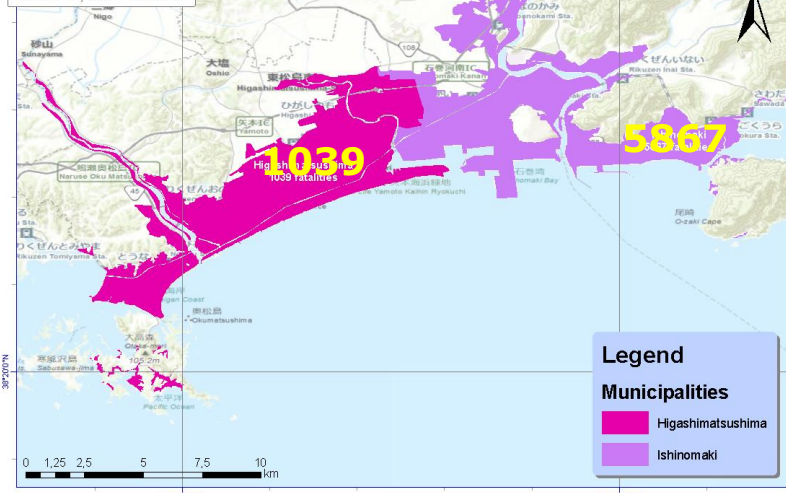
[EERI Special Earthquake Report, Nov 2011]  
[DGPR, French Ministry of Ecology, 2013]  
[The Statistics Bureau & the Director-General  
for Policy Planning of Japan]

struction Zones] + 0.25 \* [Population Density]  
05 \* [Population Gathering Points]

Municipality	Losses	Population	%
Ishinomaki	5867	160700	3,65
Higashimatsushima	1039	34000	3,06

## Ishinomaki Bay - ITI Scale - Fatalities

March 11, 2011 Tsunami





## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

## Results

## Conclusions

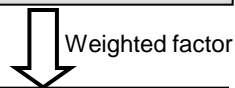
## Criteria:

- vessels
- means of transport
- heavy objects
- fires  
(due to objects)

# Methodology | Data | Thematic Map

## Displaced:

- vessels
- vehicles
- train wagons
- fighter aircrafts & helicopters
- tanks



Points data map

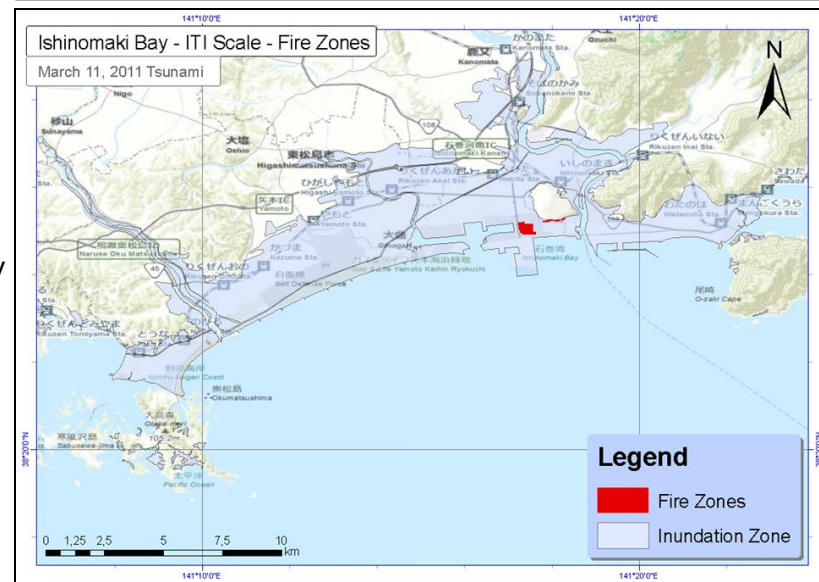
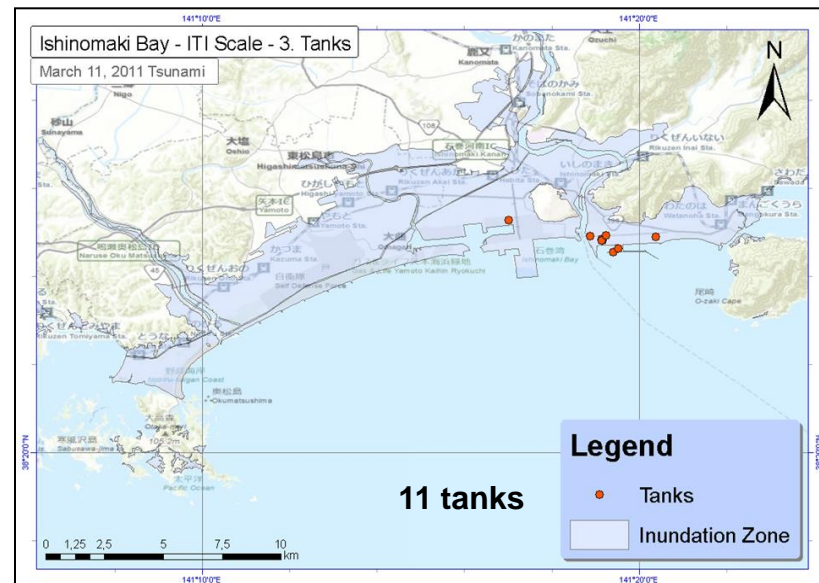
Kriging

Intensity Zoning V-XII

overlay

Fire Zones (intensity XI)

Thematic  
Map  
(Objects)



Introduction

Study Area

Methodology

1. Quantities

2. Human

3. Objects

4. Infrastructure

5. Environment

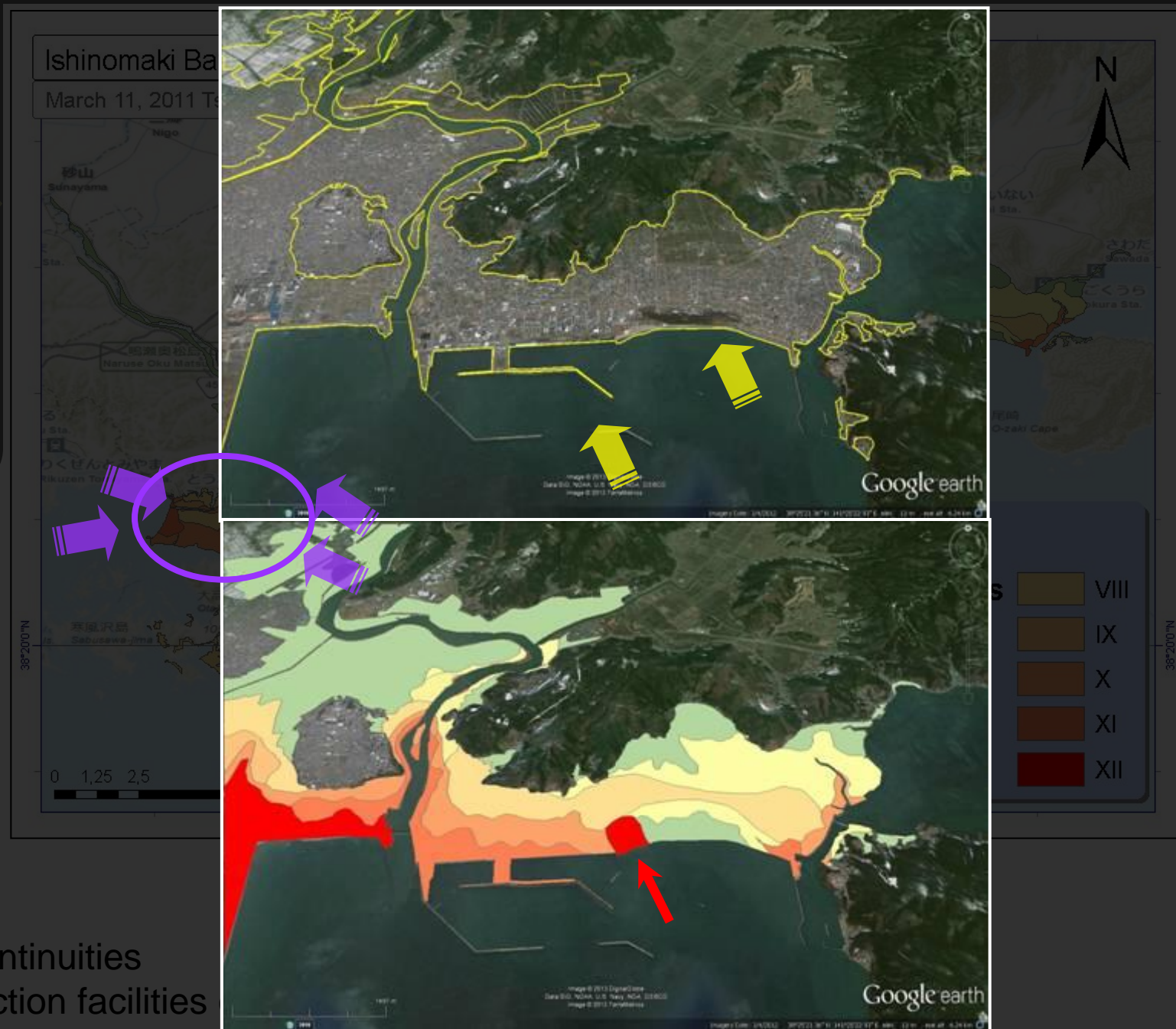
6. Structures

Results

Conclusions

3

## Methodology | Data | Thematic Map





## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

## Results

## Conclusions

## Criteria:

- port facilities
- industry facilities
- lifelines

# Methodology | Data | Thematic Map

## Damages on:

- port facilities
- industry facilities
- lifelines

### Networks:

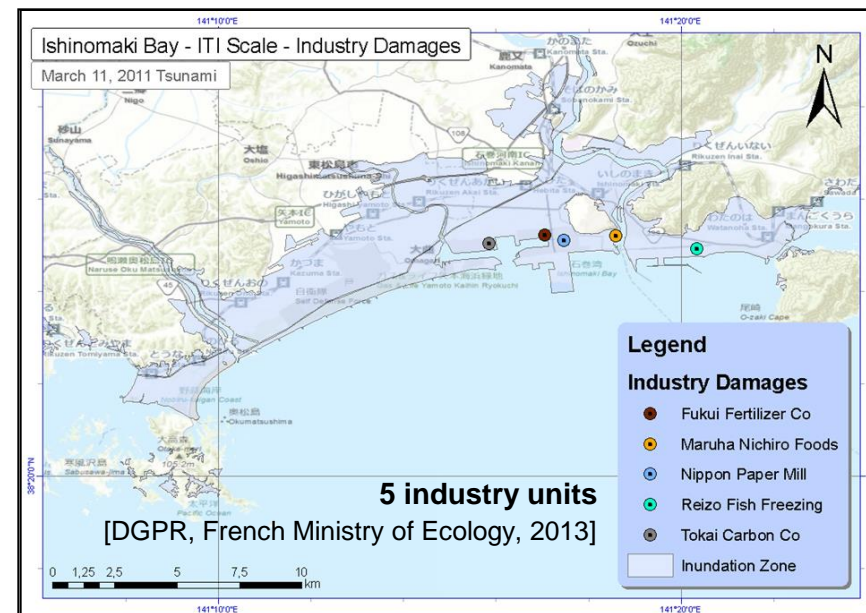
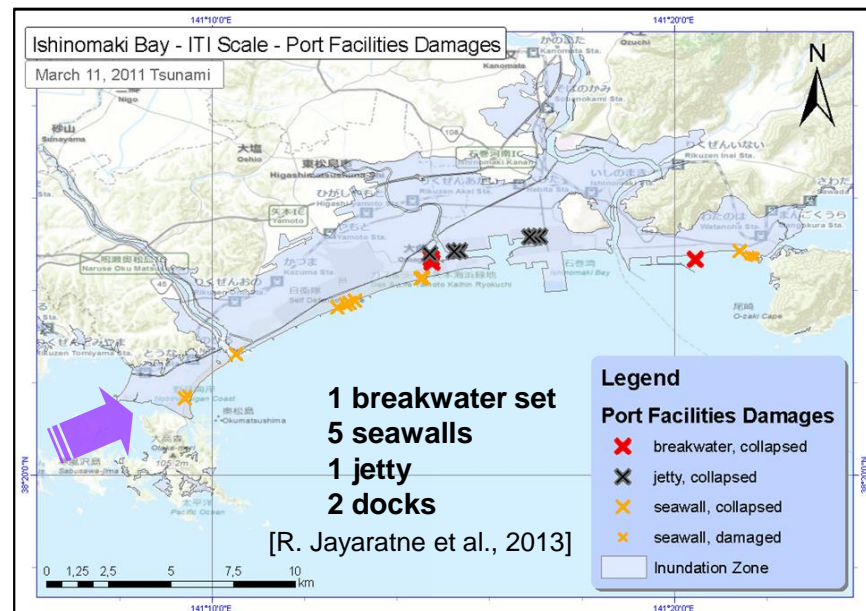
- roads / bridges
- railway
- aviation
- electricity
- water supply
- drainage
- landlines (PSTN)
- wireless
- internet access
- governmental (communication)
- LNG supply

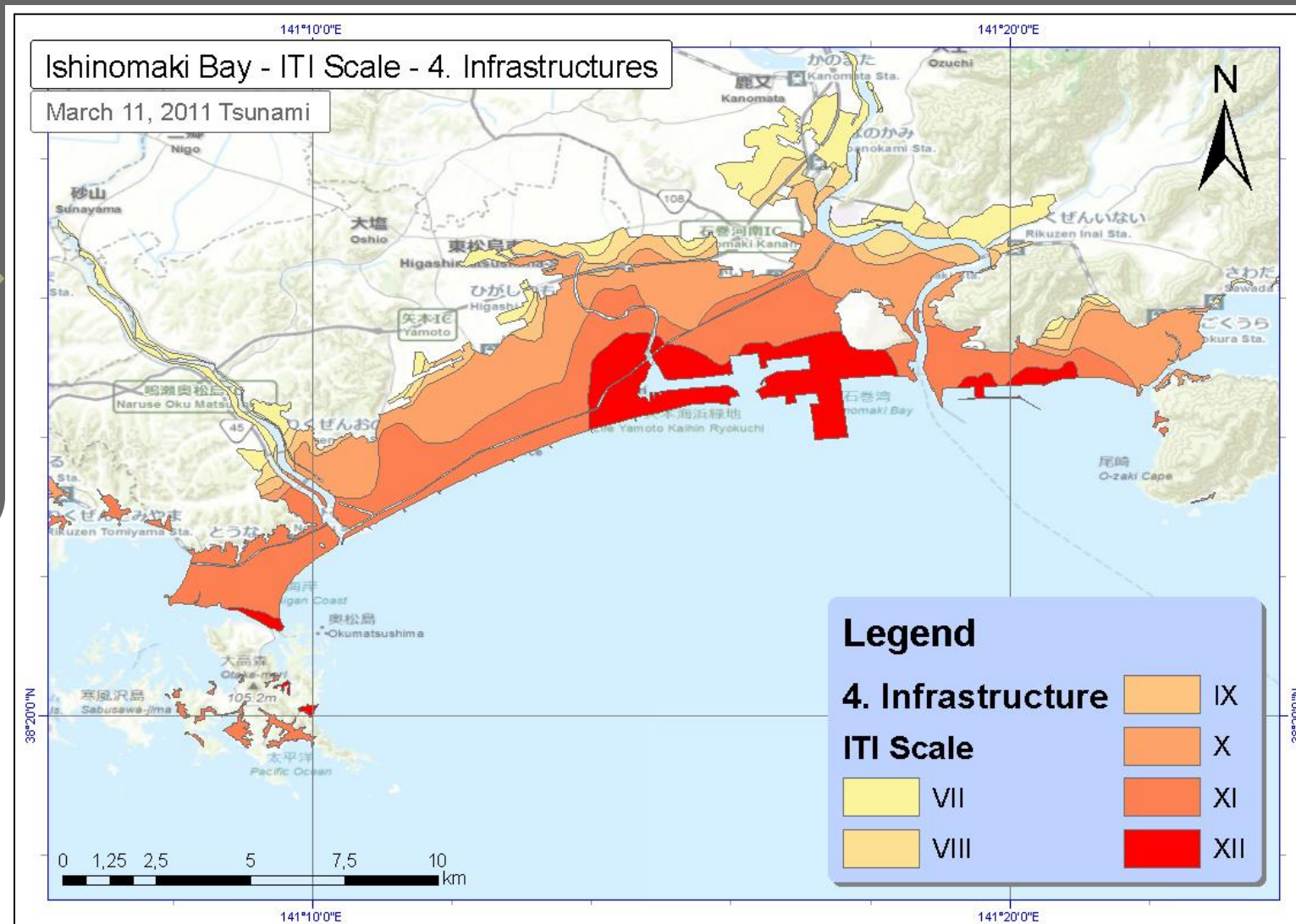


Integrated  
points map

ITIS<sub>2012</sub> IDW

Thematic Map  
(Infrastructures)







## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

## Results

## Conclusions

## Criteria:

- erosion/ shoreline changes
- deposits
- trees / bushes
- boulders
- debris
- pollution
- in-situ fires

## Methodology | Data | Thematic Map

A

IDW

Points Data  
Zoning Map

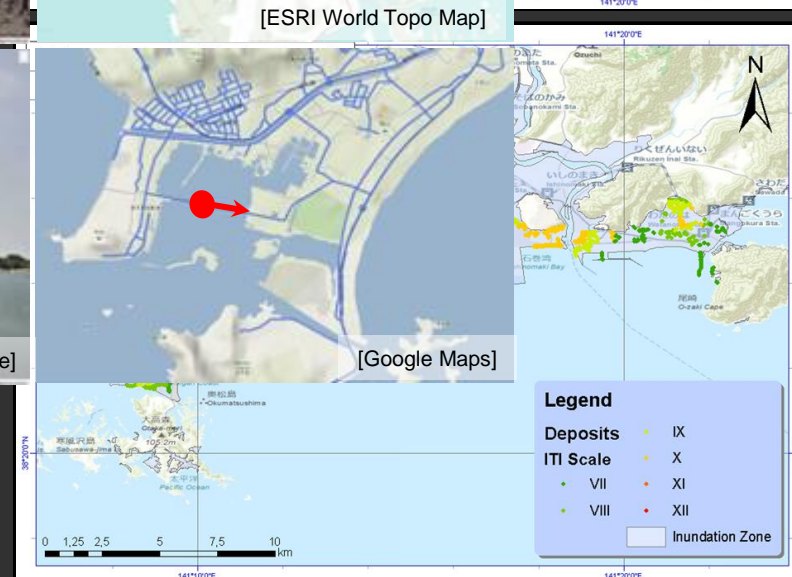
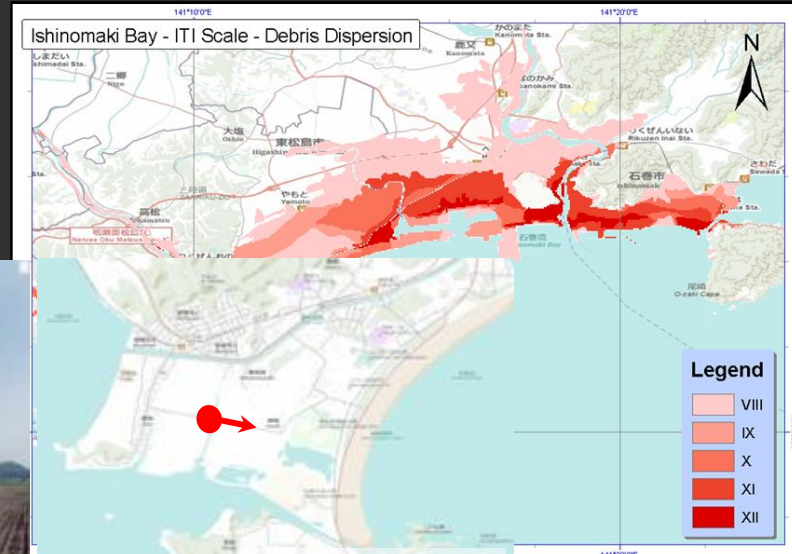
Located:

- shoreline changes

S<sub>2012</sub>



- uprooted trees
- bridges near the shoreline
- steep-relief areas behind residential zones



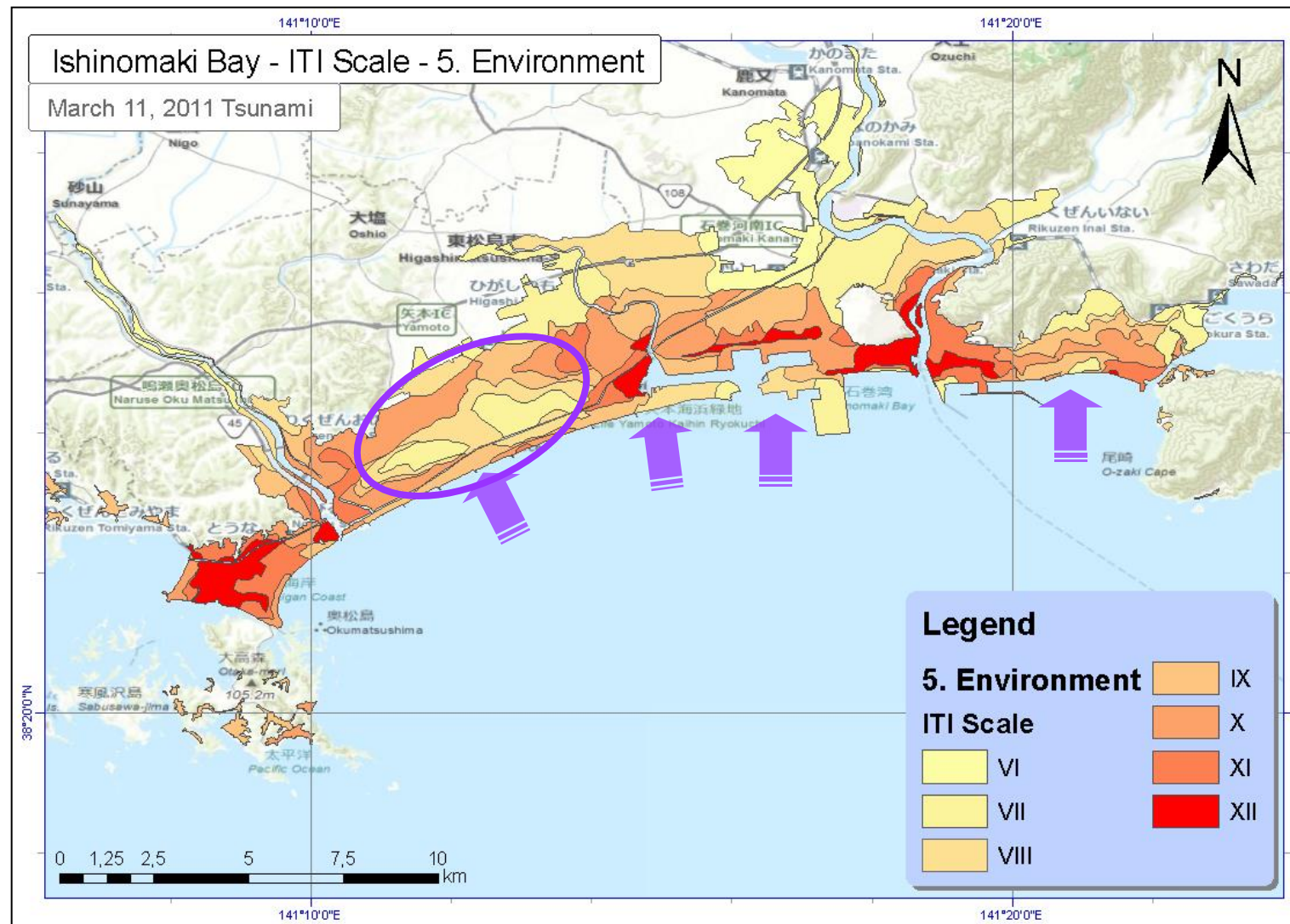
Ishinomaki: 6.16 million tones  
Higashimatsushima: 1.68 million tones  
[Toru Inui et al., 2012 & UNEP, 2012]

$$0.80 * A + 0.20 * B \longrightarrow$$

Thematic  
Map  
(Environment)

## 5

## Methodology | Data | Thematic Map



- lack of data in airport area
- low intensity grades at the shoreline (infrastructures, land use)

## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

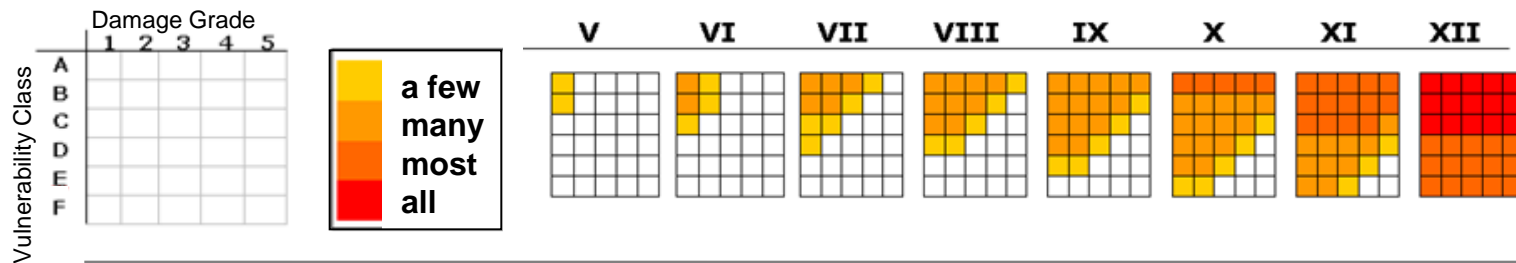
### 5. Environment

### 6. Structures

## Results

## Conclusions

# Methodology | Data | Thematic Map



- mapping [ESRI World Topo Map & Google Earth]
- distinction of washed-away & demolished structures [Google Earth & Google Memories for the Future]
- isolation of construction-free areas [Google Earth]



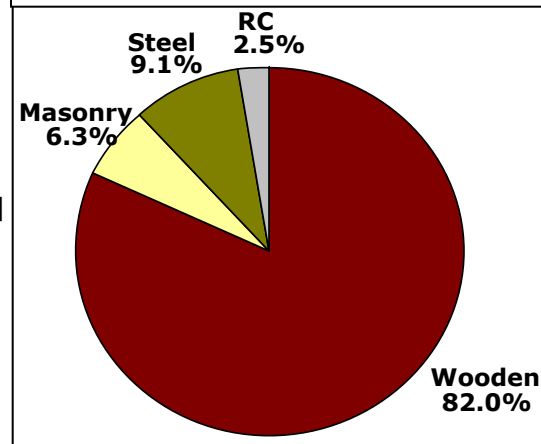
Density Map of removed structures

- evaluation based on:
  - structural material
  - damage grade

Thematic Map (Structures)

[Google Memories for the Future & Google Street View]

Structures Distribution based on structural material in Ishinomaki



[N. Leelawat et al., 2014]

### Criteria based on:

- structural material
- damage grade
- spatial density of the above



## Introduction

## Study Area

## Methodology

1. Quantities
  2. Human
  3. Objects
  4. Infrastructure
  5. Environment
  6. Structures
- ## Results
- ## Conclusions

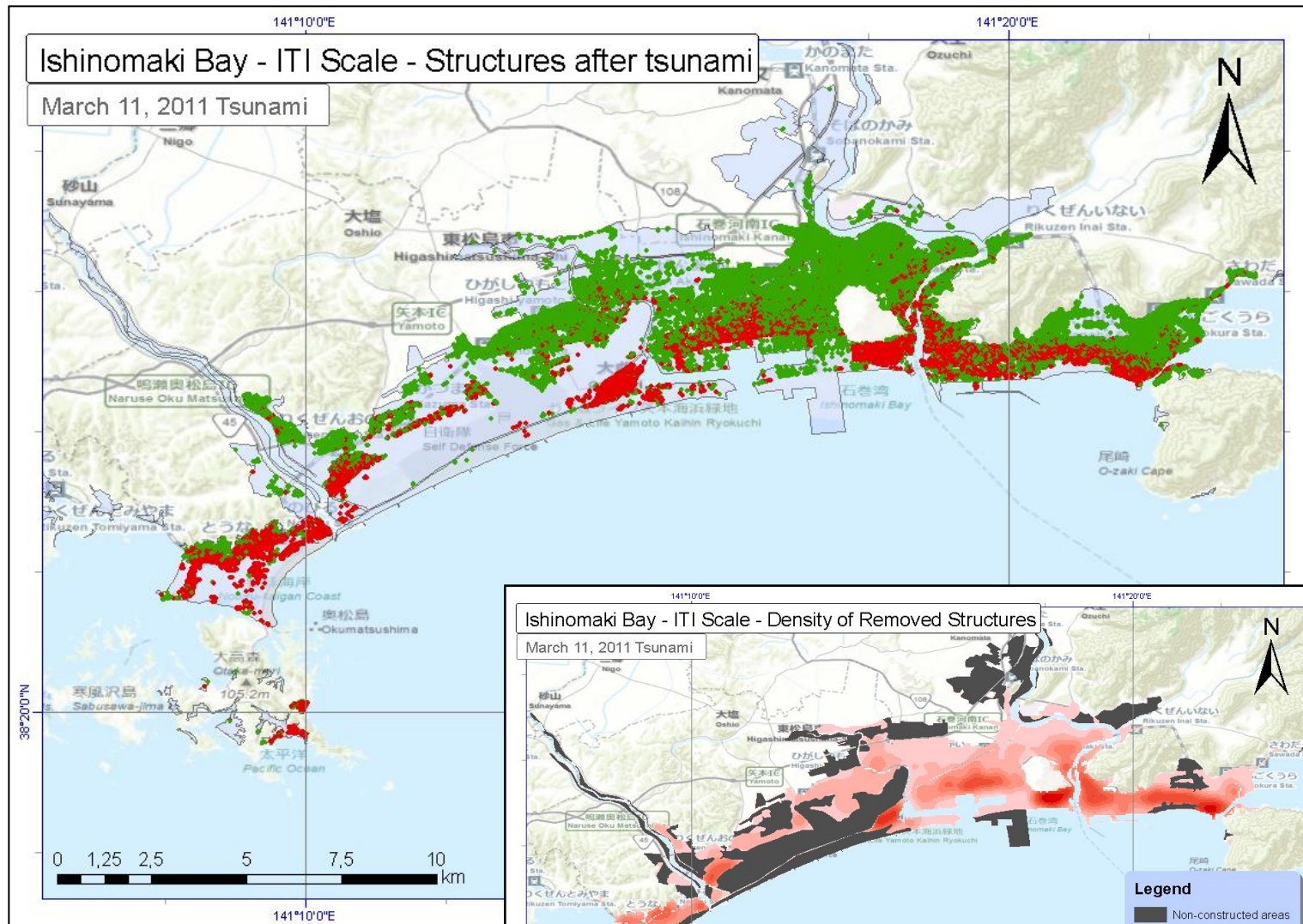
### Criteria based on:

- structural material
- damage grade
- spatial density of the above

# Methodology | Data | Thematic Map

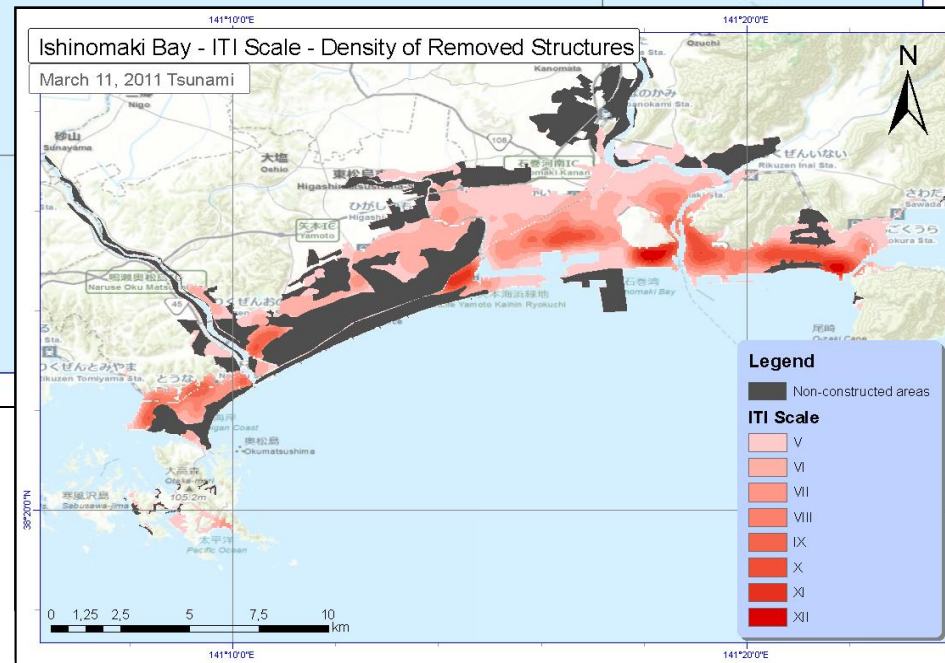
## Ishinomaki Bay - ITI Scale - Structures after tsunami

March 11, 2011 Tsunami



## Ishinomaki Bay - ITI Scale - Density of Removed Structures

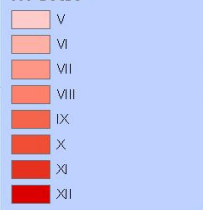
March 11, 2011 Tsunami



### Legend

Non-constructed areas

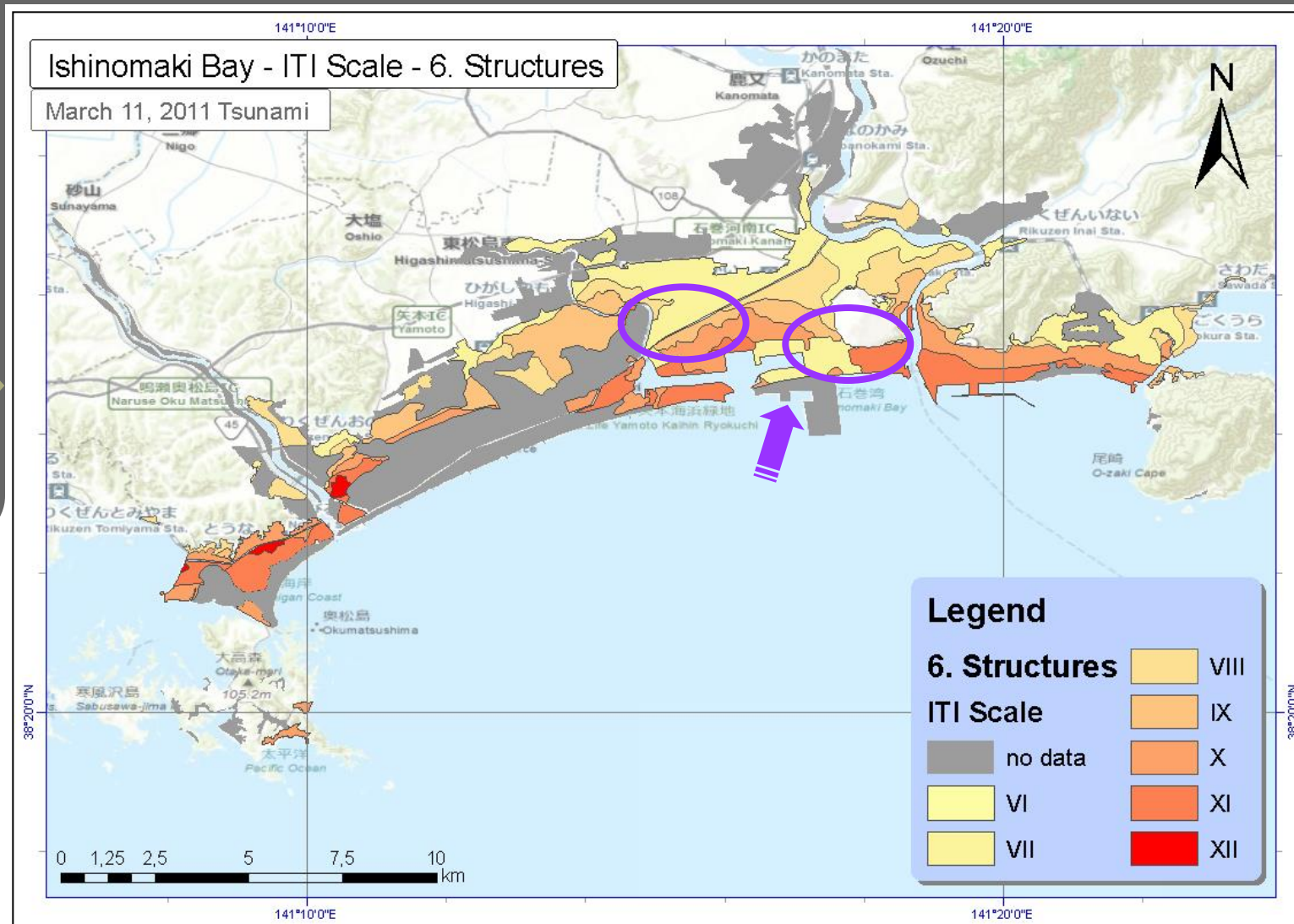
### ITI Scale



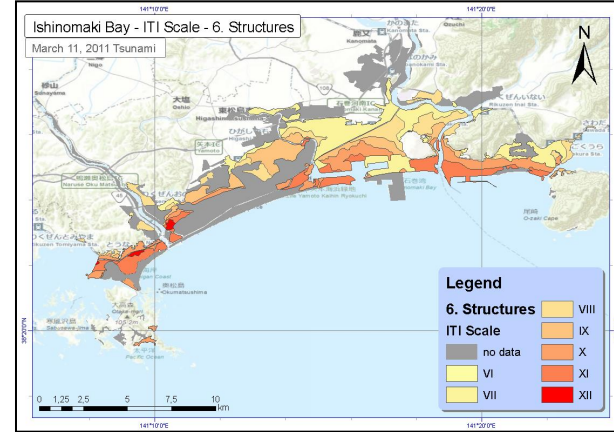
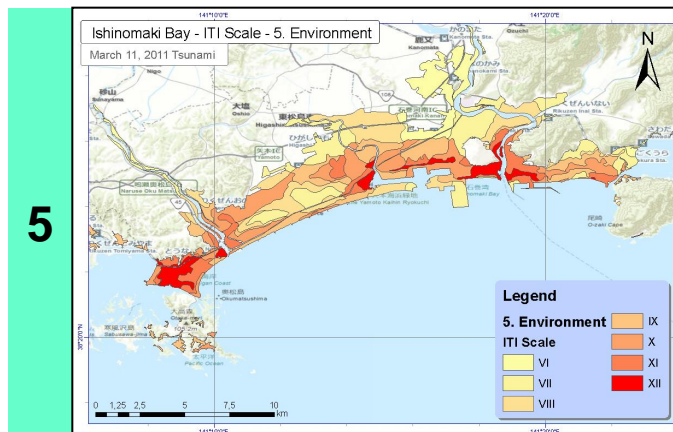
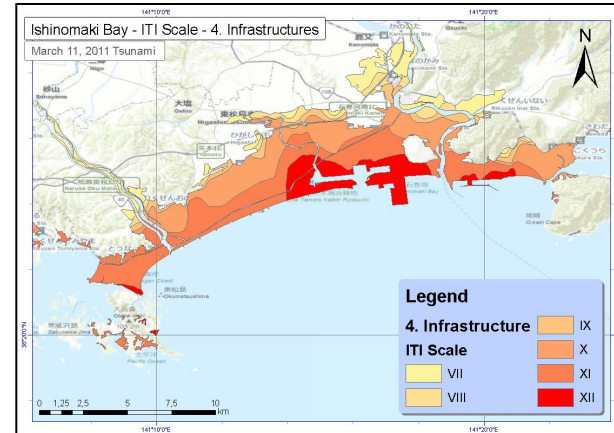
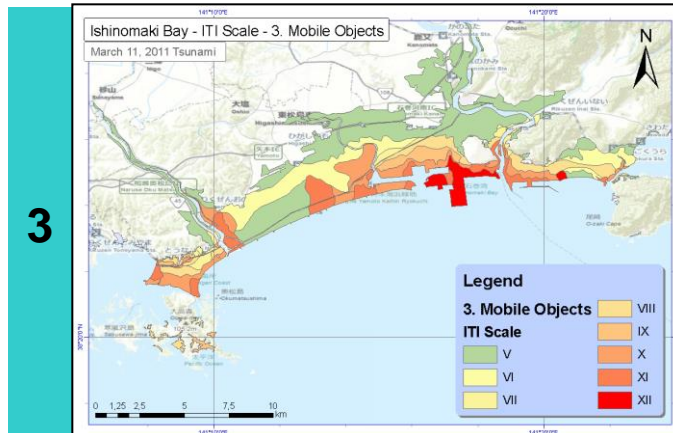
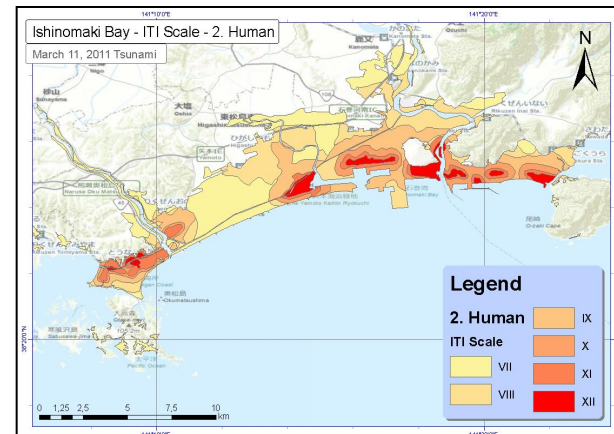
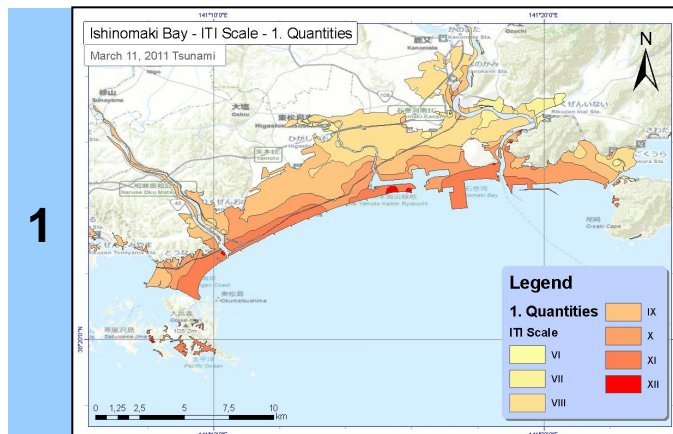


## 6

## Methodology | Data | Thematic Map



- steady structure quality in the industrial zone
- discontinuity due to wooden houses near the industrial zone
- XII grade is based on the RC structure damage



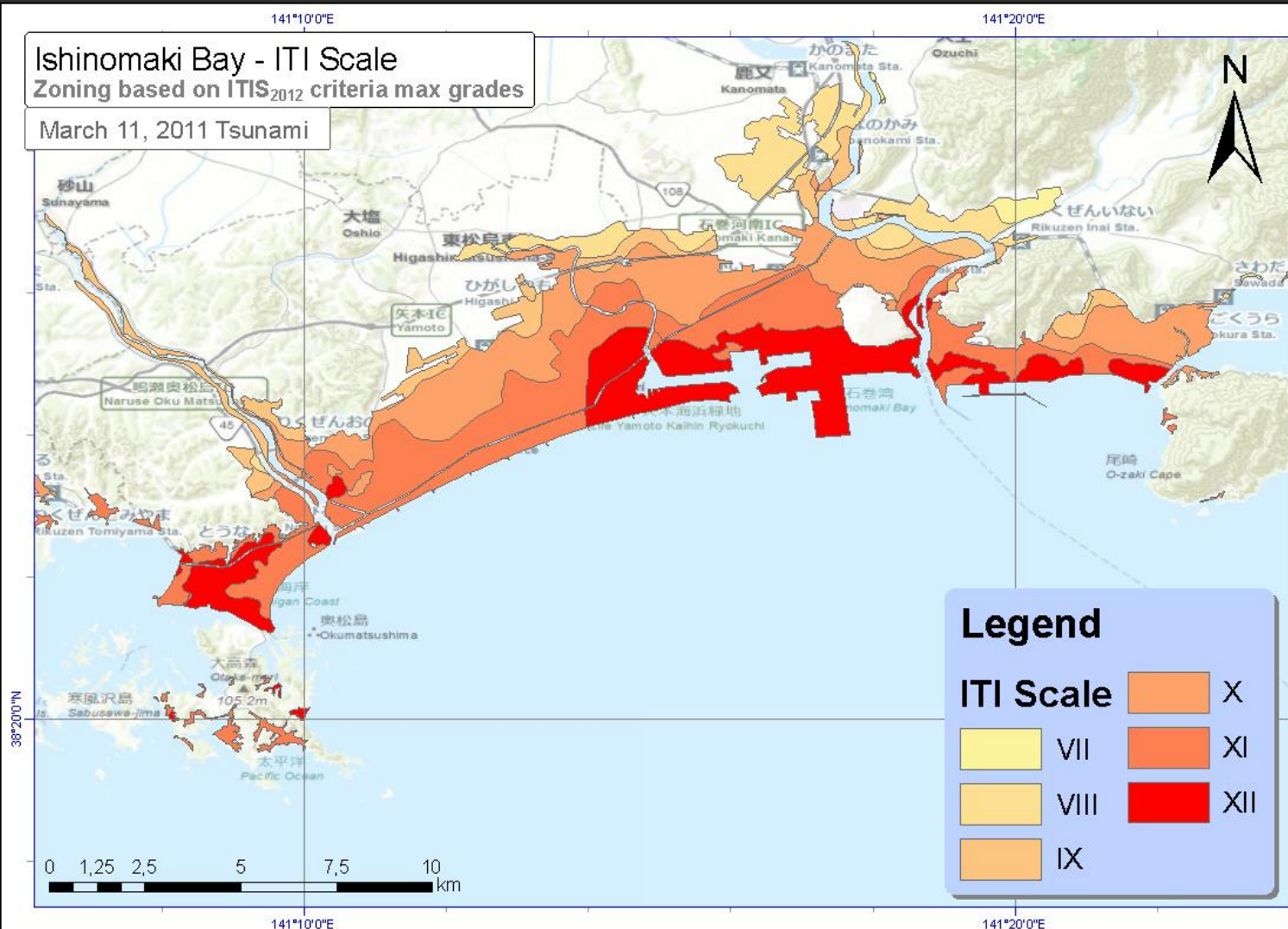


# Methodology | Results | Analysis

## Ishinomaki Bay - ITI Scale

Zoning based on ITIS<sub>2012</sub> criteria max grades

March 11, 2011 Tsunami



based on the ITIS<sub>2012</sub> criteria complementarity.  
(hazard assessment of the study area)

**Hazard Assessment of the Study Area**

## Introduction

## Study Area

## Methodology

### 1. Quantities

### 2. Human

### 3. Objects

### 4. Infrastructure

### 5. Environment

### 6. Structures

## Results

## Conclusions

## Methodology | Results | Analysis

○ at shoreline:  
low-grade intensities

**A**

- land use
- protection facilities

○ fluctuation inland  
- lack of data (airport)

○ inland:  
increased intensity  
- hydrographic network  
proximity  
- geomorphology  
& land use

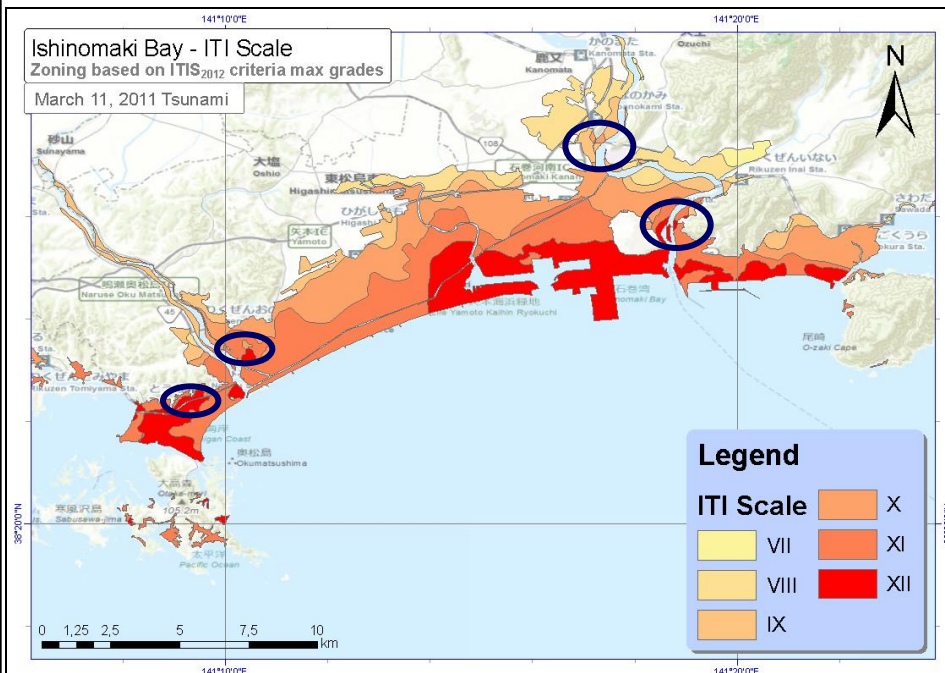
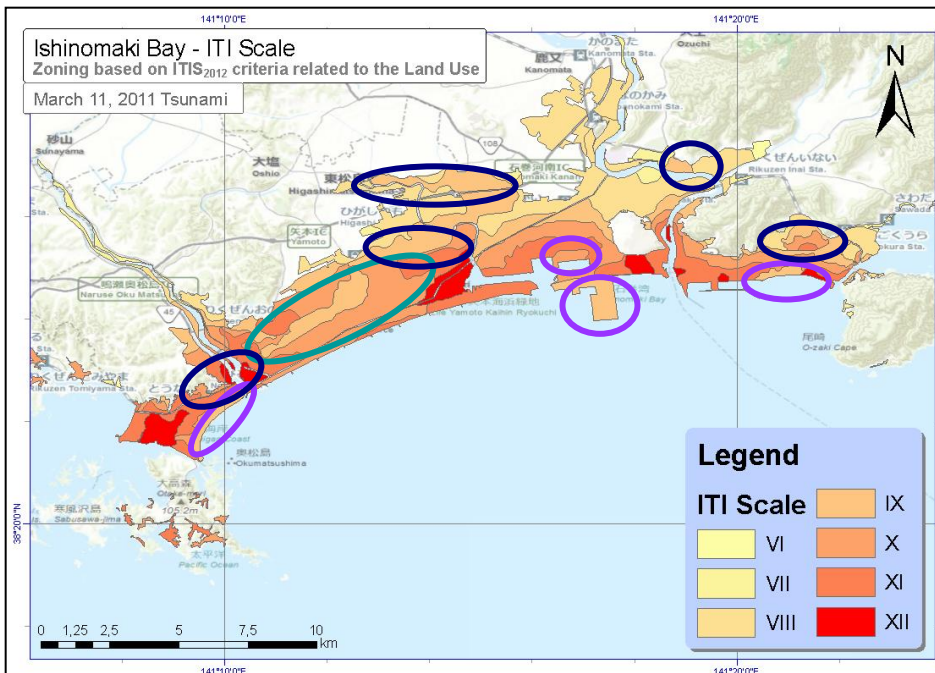
at shoreline:

XI (forests / port facilities) - XII

**B**

decreased intensity inland

○ inland:  
increased intensity  
- hydrographic network  
proximity  
- geomorphology





## Introduction

## Study Area

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### 1. Quantities

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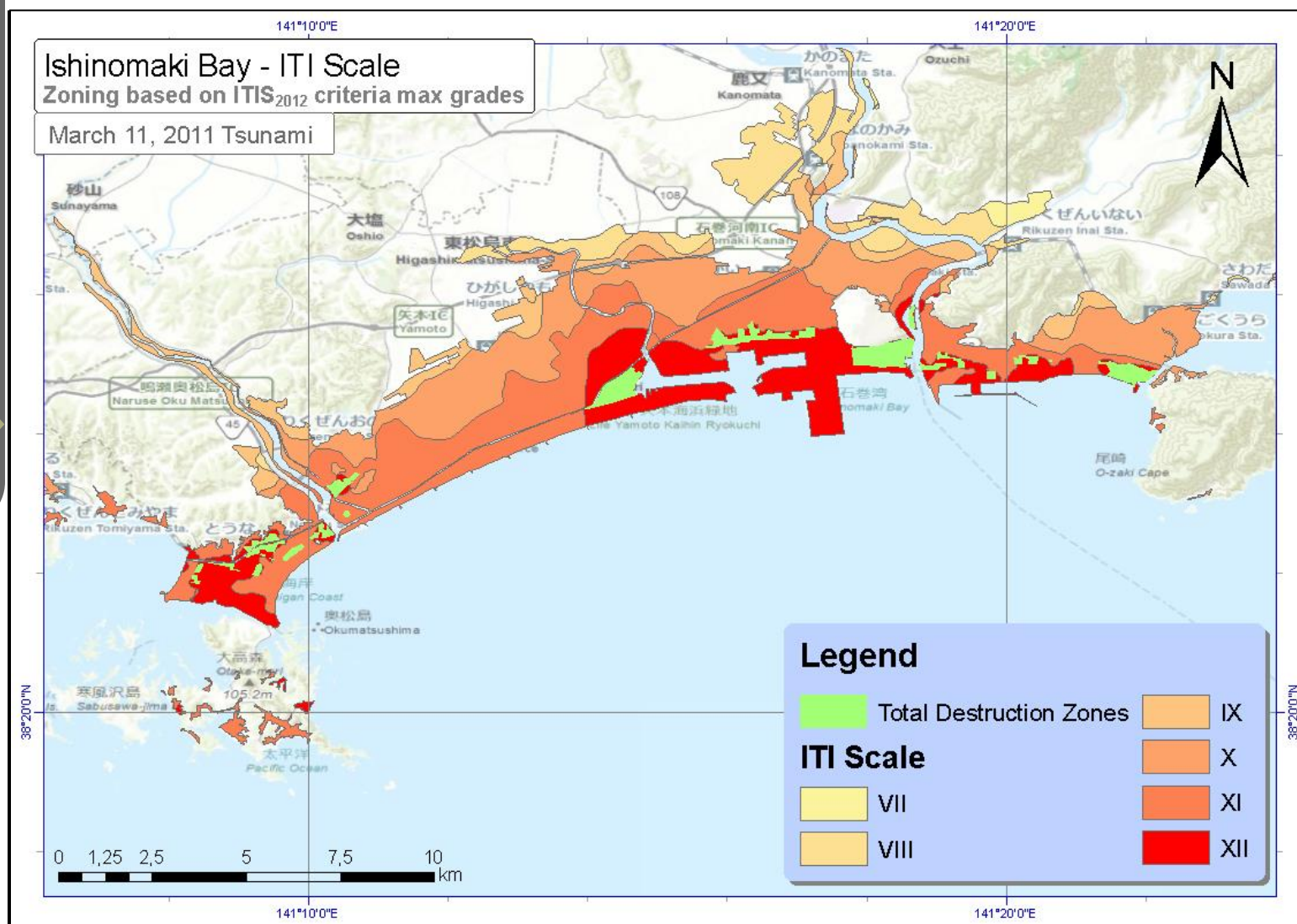
### 6. Structures

## Results

## Conclusions



# Methodology | Results | Analysis



+

-

Quantities	Impact on				
	Human	Objects	Infrastructure	Environment	Structures
1					
2					
3					
4					
5					
6					

positive coastal forests response - plain area – rivers & canals

positive port facilities response - protection facilities lack

protected city center - vulnerable industry

excellent prevention measures - vulnerable structures >80%

Artificial Barriers - lifelines

highway 45

response

ERD

gap

vulnerable >80%

Port Facilities Adequacy

Urban Planning

Prevention Measures

EWS & training

underestimation

- industry facilities & personnel training

- strict earthquake-resistance legislation

annual citizens' training program - limited drills participation

early warning system - hazard underestimation

prevention &  
management  
measures

damage &  
losses  
mitigation

unpredictable  
magnitude  
of the event

ITIS<sub>2012</sub> Applicability per Criteria Category

	Quantities	Impact on				
		Human	Objects	Infrastructure	Environment	Structures
Easily Applicable						
Complementarity						
Not Saturated						
Indirect Approach						
Confirmed by Studies/Data						

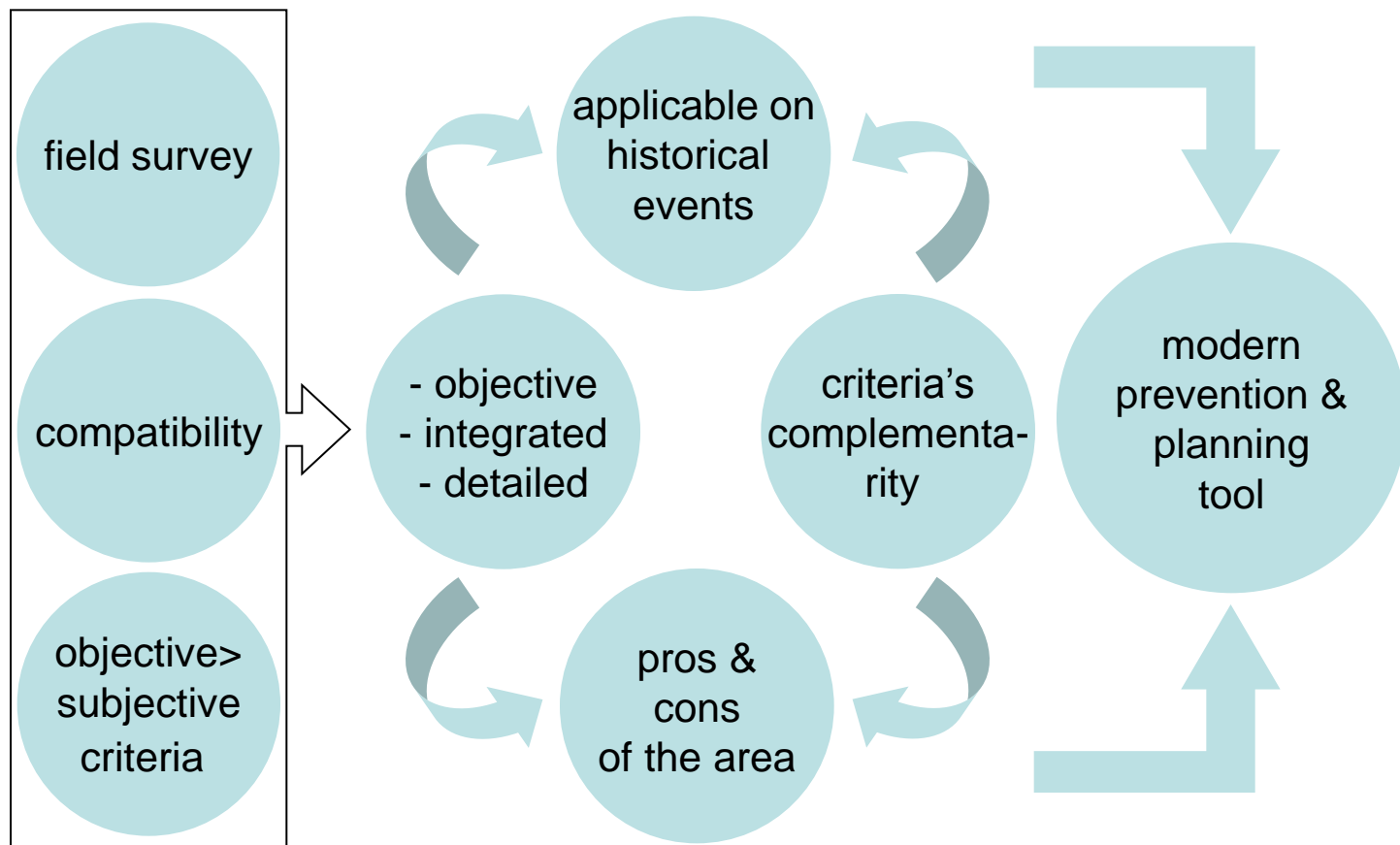
ITIS<sub>2012</sub> Criteria Categories Evaluation

	Quantities	Impact on				
		Human	Objects	Infrastructure	Environment	Structures
Propagation & Destructiveness						
↳ Disaster Sources				*		
Innovation						
Management & Restoration						
Historical Events						
Land Use (urban planning)						
Earthquake vs. Tsunami Damages						
Lack of Data (Restoration Works)						
Lack of Data (in Construction-free Areas)						

\* NaTech

In-time  
Field DataCriteria's  
Complementarity







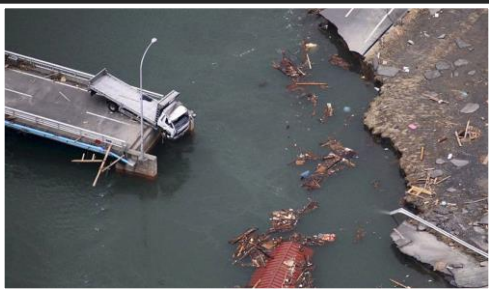
[KYODO/Reuters]



[Kim Jae-Hwan, Toru Yamanaka/AFP/Getty Images]



[The Asahi Shimbun]



[Hiroshi Adachi/Yomiuri Shimbun via Associated Press]



EU – Delegation of the European Union to Japan  
<http://www.euinjapan.jp/en/media/audio/photo/20120311/070000>

# Thank you!