# Supporting land administration and facilitating quick recovery from the damage in the aftermath of the 2011 Tohoku Earthquake

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# Contents



1. Efforts for the revision of results of national geodetic control points: in case of 2011 Tohoku Earthquake

2. Significance of cadastral survey: Essential base for quick disaster recovery

3. Summary

# Contents

# 2011 Tohoku Earthquake

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- 2011 off the Pacific coast of Tohoku Earthquake (or Great East Japan Earthquake)
- Occurred on March 11, 2011; Magnitude 9.0
- Tsunami height >10 m; inundated 561 sq. km.
- People death 19,335; missing 2,600 (as of 1 Sep 2015)
- Houses destroyed 124,690, half damaged 275,118, partial damaged 764,843 (as of 1 Sep 2015)

# Surface movement by the earthquake

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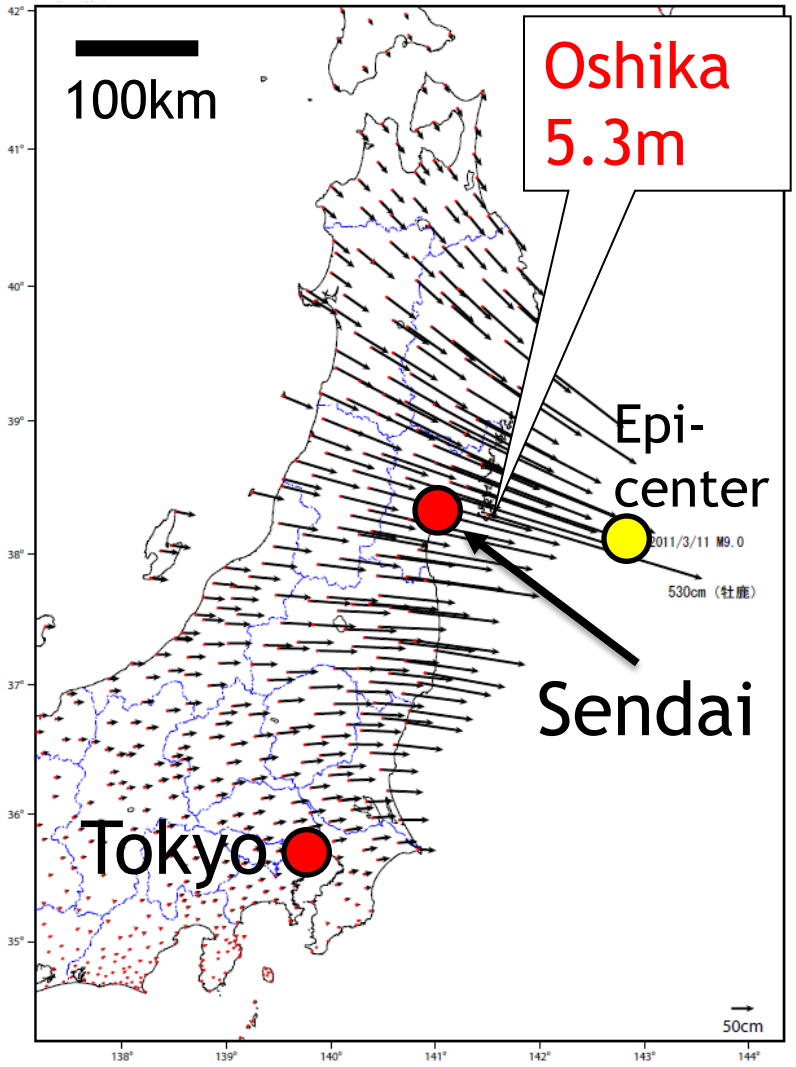
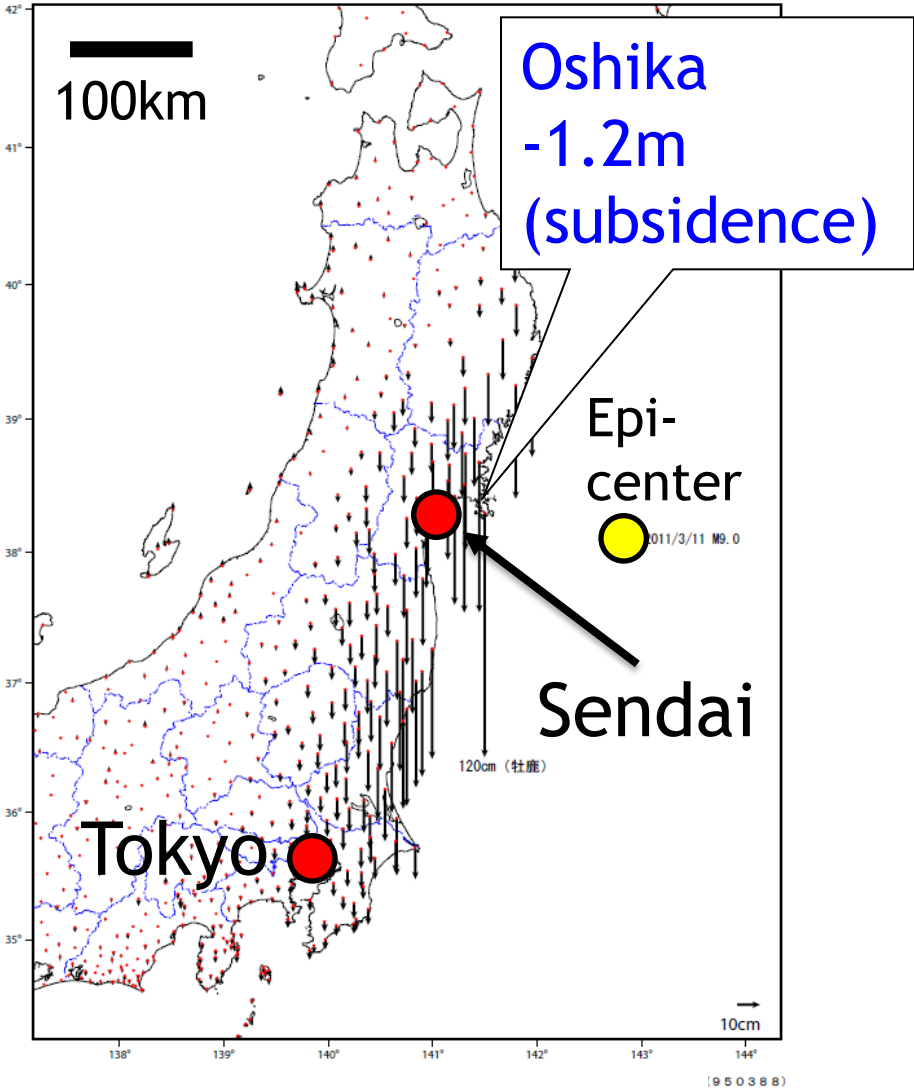
## Horizontal




## Vertical




Control points survey results must be revised over the large area

# Control points and Land Boundary Survey

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## The process to conduct land boundary survey

(1) GNSS-based control point (GEONET Station)

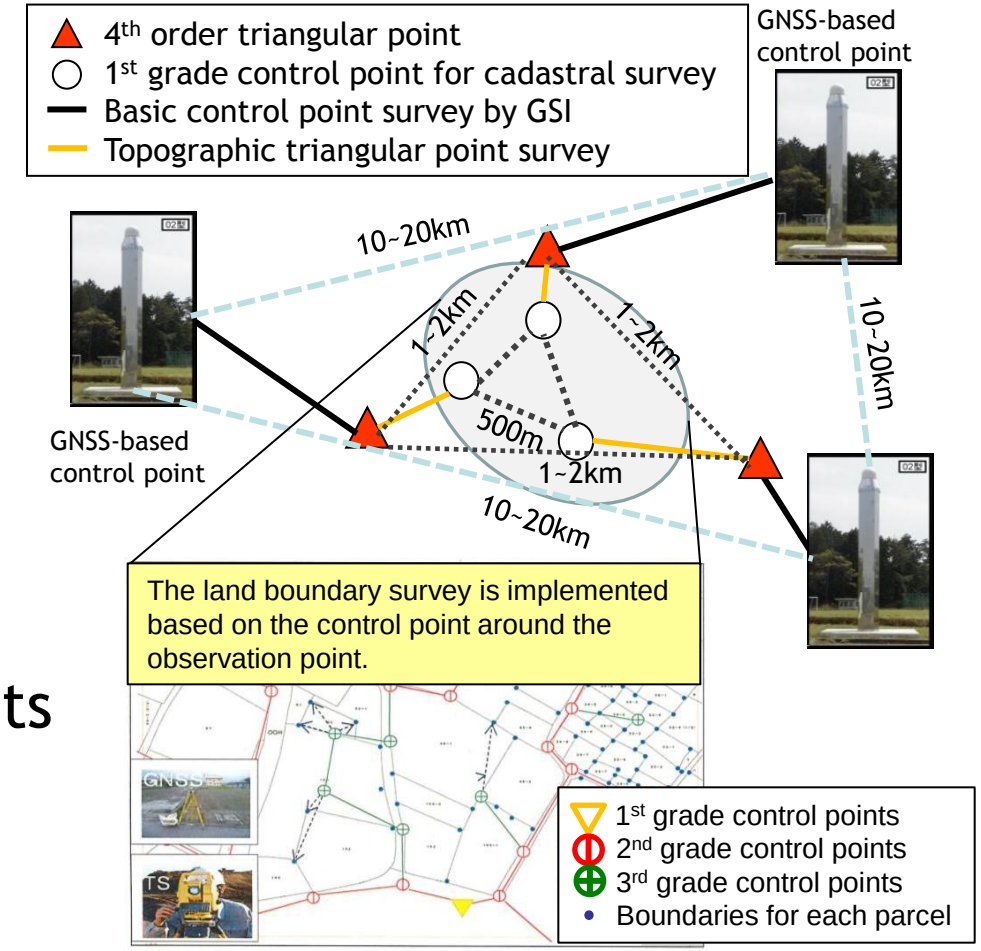
(2) Triangular Control Points Survey

(3) Topographic Triangular Points Survey

(4) Topographic Traverse Points Survey

**Results became ineffective**

(5) Land Boundary Survey




**Early revision of control point survey result was required for disaster recovery**

# Estimation of amount of after slip

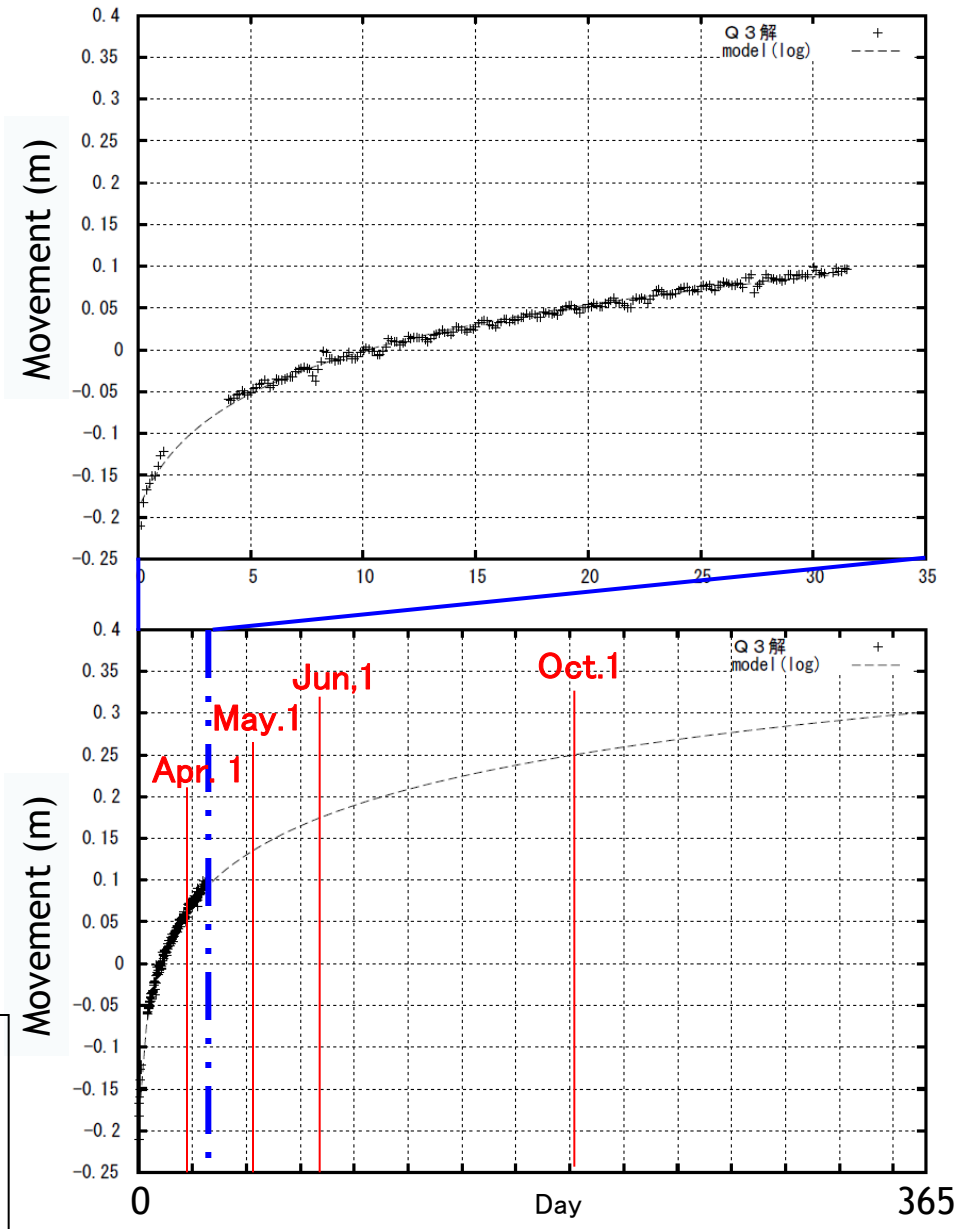
Logarithmic model function was well adopted to estimate the future trend of after slip.

$$y(t) = c + a \ln\left(1 + \frac{t}{\tau_{\log}}\right)$$

(c, a:constant, $\tau_{log}$: constant(time), t: time)

***We decided that the survey data should be revised in the end of May 2011, considering the future amount of strain.***

Made use of continuous crustal deformation data from GNSS-based control stations




Estimated after slip at the site “Yamada”(#950167)

# Survey data revision (GNSS-based control stns.)

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**East Japan**

Survey data was closed (Mar. 14)

GNSS & VLBI* observations & analyses.

Adjust poor precision around the border of revised/non-revised area.

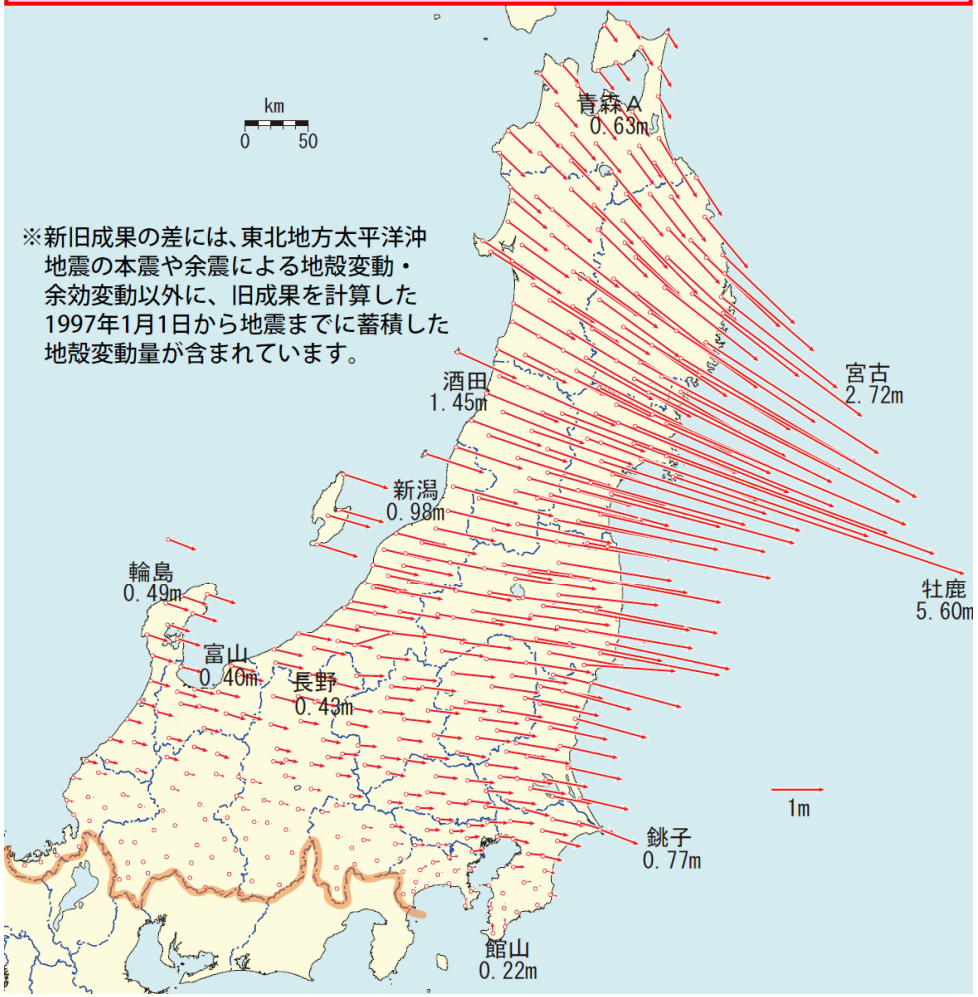
Revising area was extended

New survey data was opened (May. 31)

**West Japan & Hokkaido**

Not revised

**Difference vectors: between old and new**




**All data set is called “Geodetic Coordinates 2011”**

*VLBI: very long baseline interferometry

# Survey data revision (Triangulation stns.)

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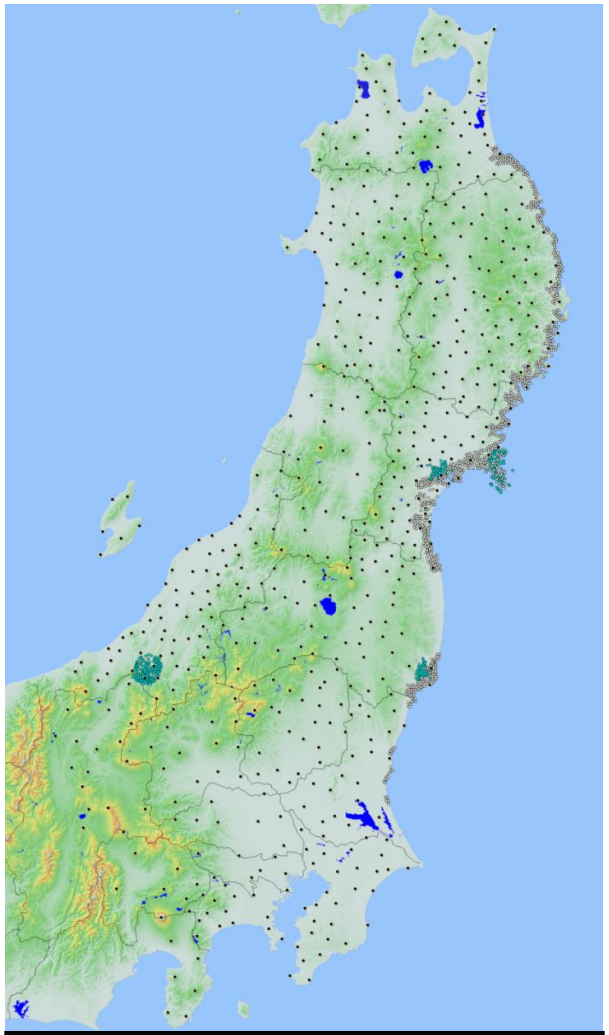
The Question: How to revise the results of 44,000 suspended triangulation points in a limited period?

Conduct GNSS observations at about **600 selected triangulation stations**

Calculate **correction parameters** using the results of GNSS-based control stations and GNSS observations above.

**Adapt the parameters** to non-observed triangulation stations

**Check the results** by supplementary GNSS observation.

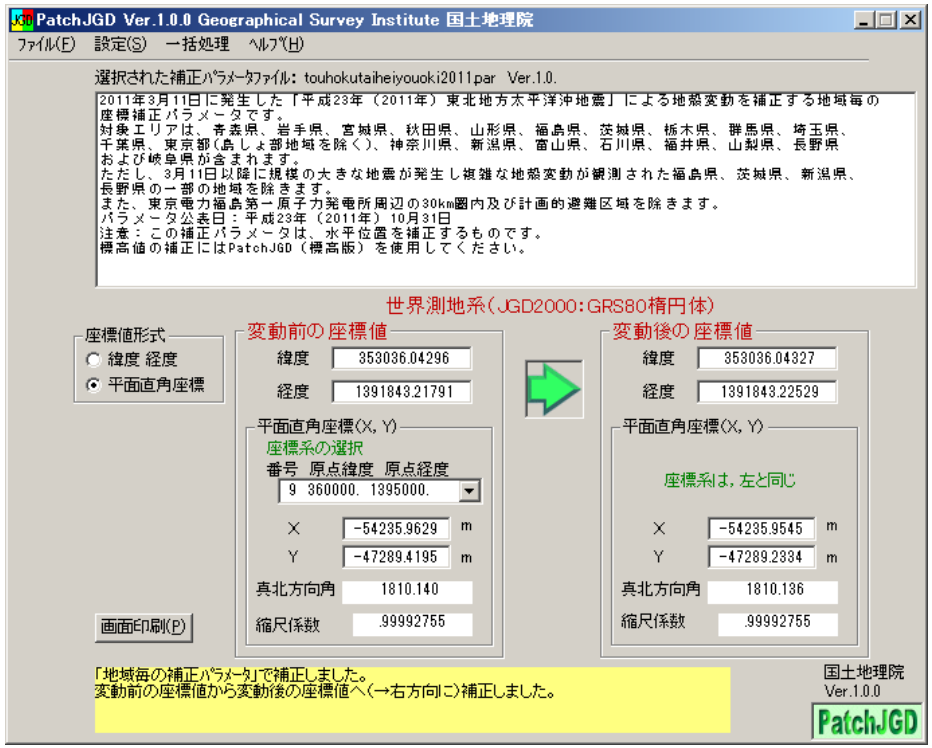


600 “high order control points” for GNSS observation

# Tools for revision with correction parameters

GSI is providing following tools to revise survey results

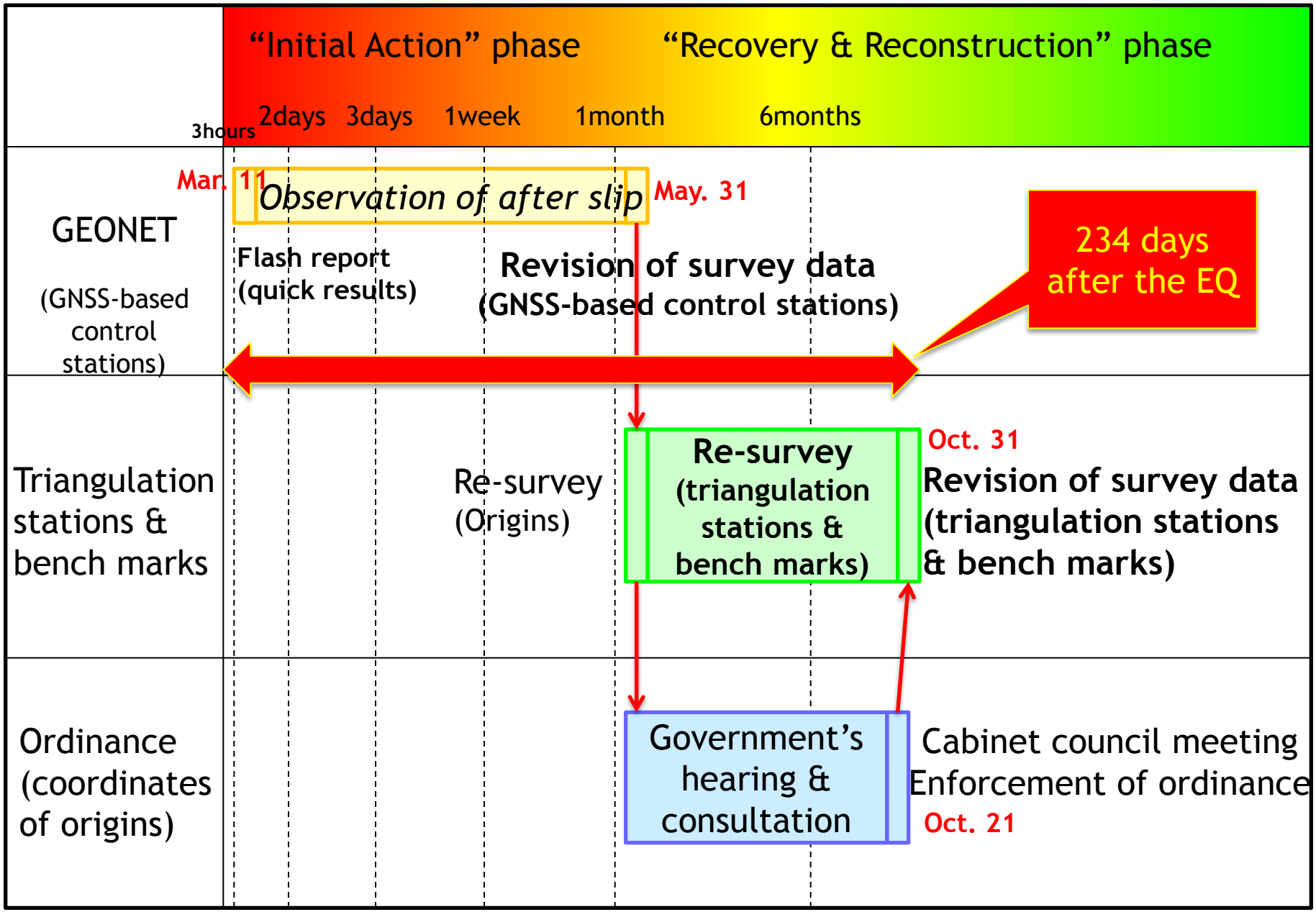
- Software “PatchJGD”
- Correction parameter files




PatchJGD (Main display)

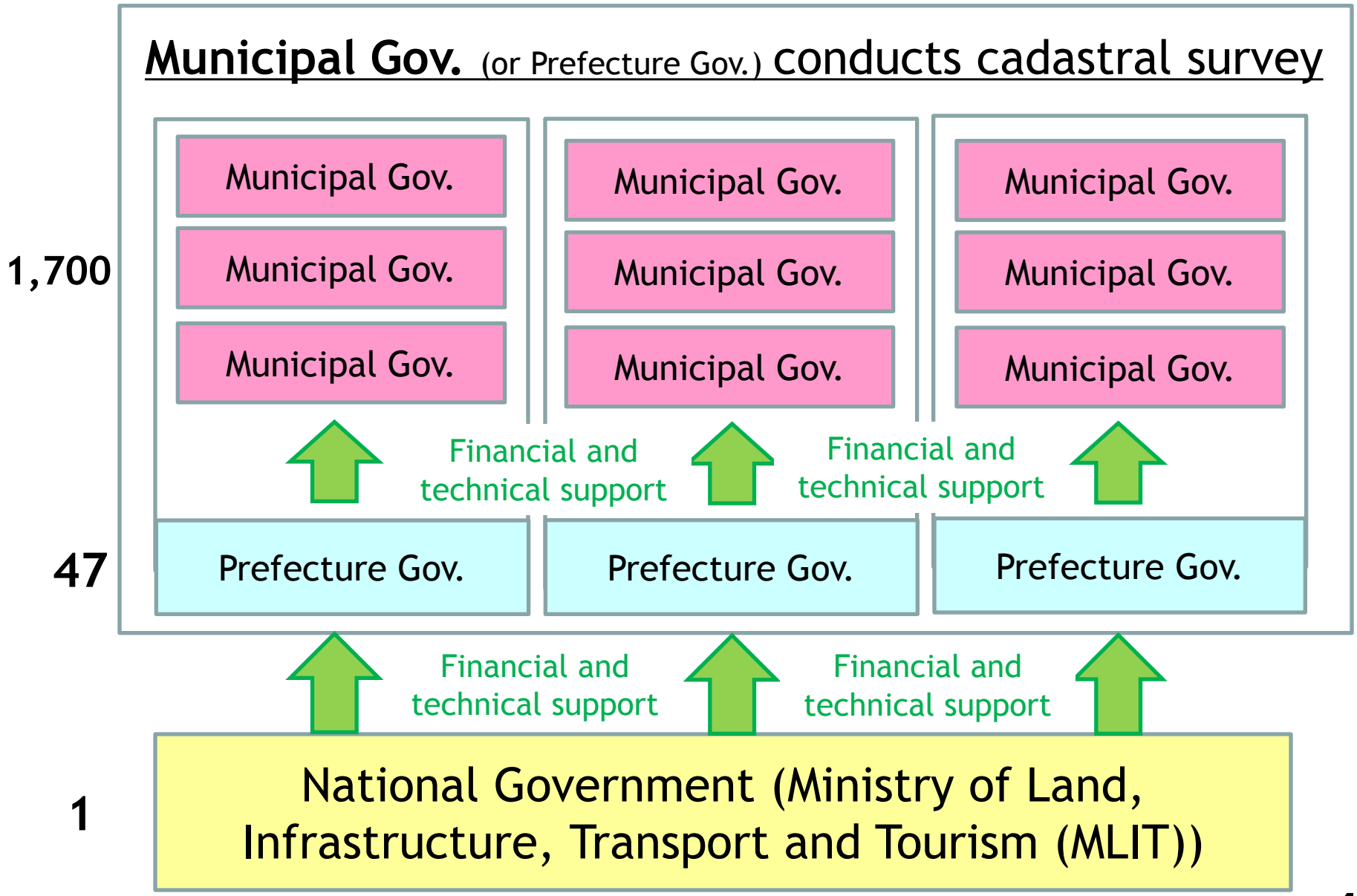

Download page at GSI’s website.

# Revision of survey data (Chronology)



# Contents

# Cadastral Survey Administration in Japan



# Progress of Cadastral Survey in Japan

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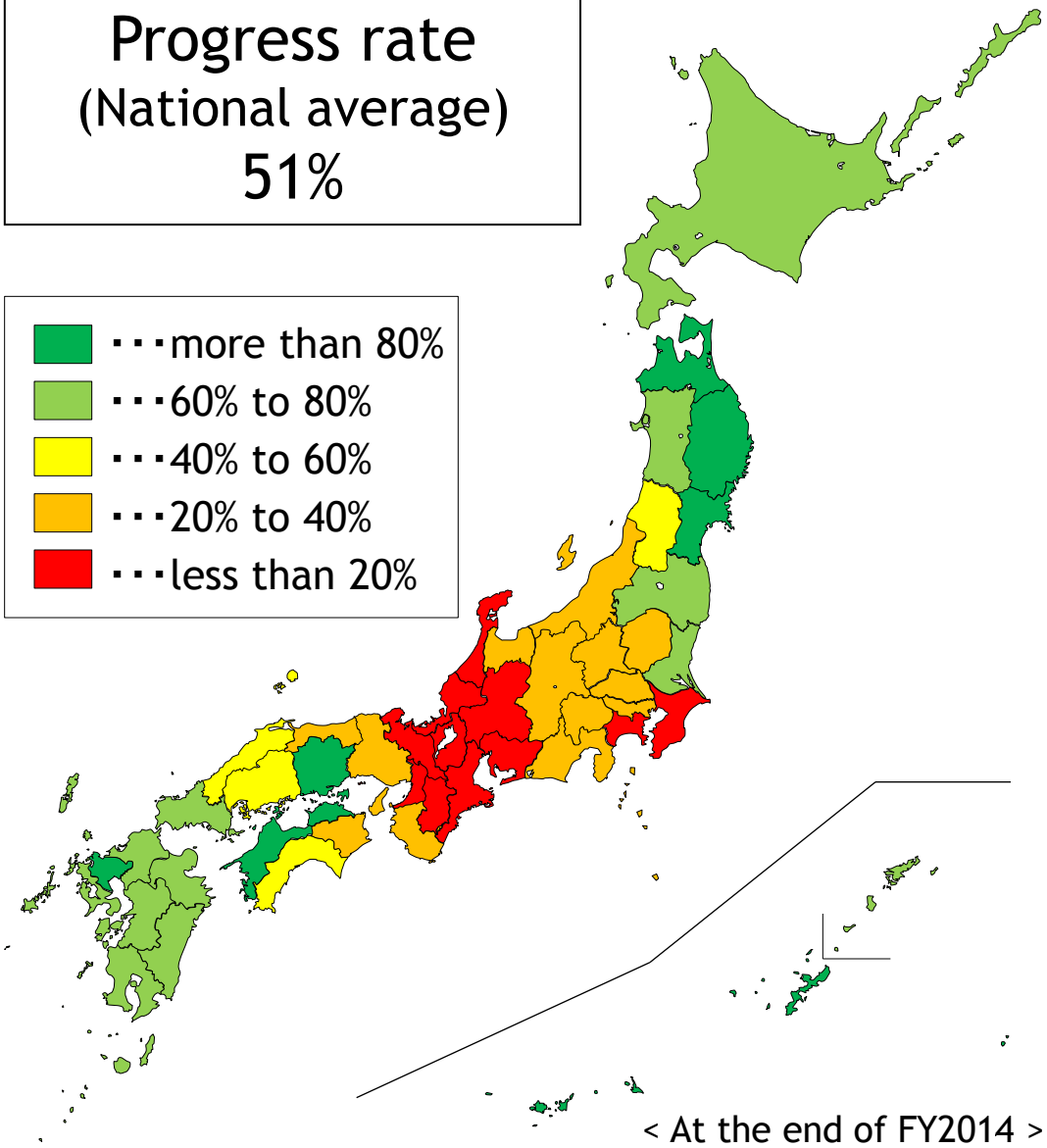
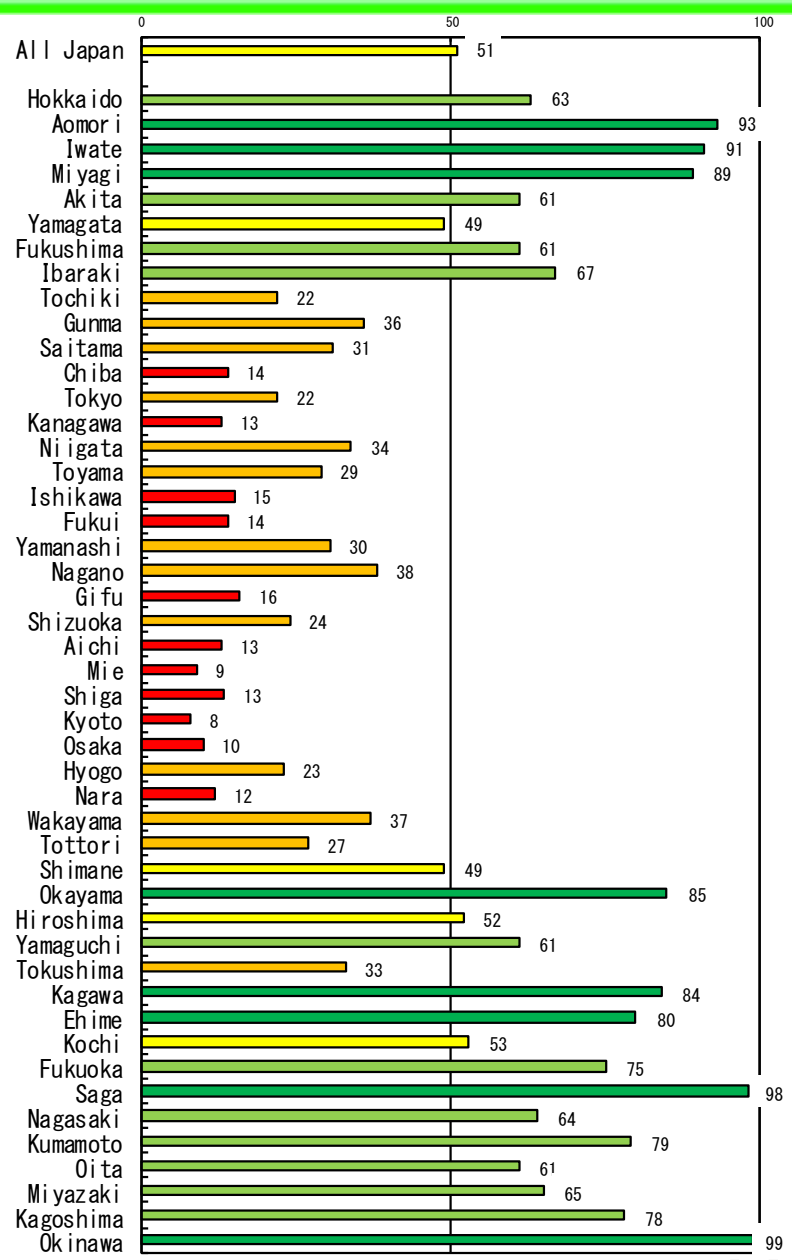
**Progress rate**
(National average)
**51%**

- ・・・more than 80%
- ・・・60% to 80%
- ・・・40% to 60%
- ・・・20% to 40%
- ・・・less than 20%



< At the end of FY2014 >



# Effects of Cadastral Survey (1)

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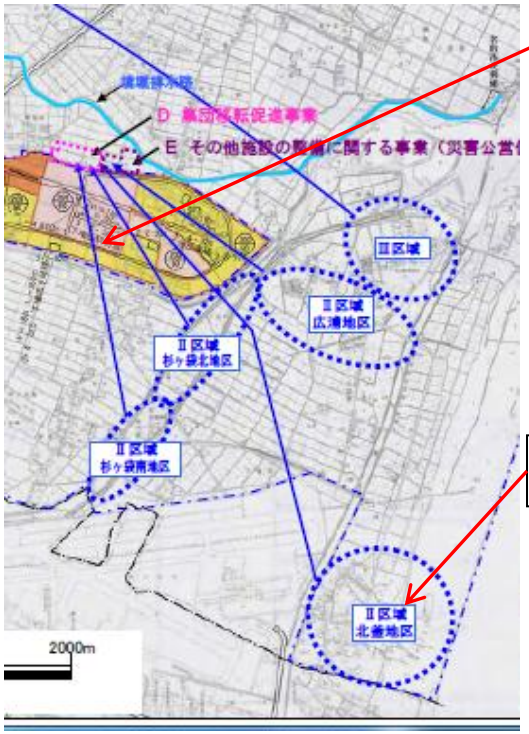
## Collective Relocation for Disaster Mitigation
-Natori City, Miyagi Prefecture-




Cadastral Survey
Progress Ratio : 93%

Inland area (after disaster)

relocation

Coastal area (after disaster)

### Effect of Cadastral Survey

**With** pre-existing cadastral data

12 million yen,
7 months

Saved : 10 million yen
0.5-1 year

22 million yen,
1～1.5 year (estimation)

**Without** pre-existing cadastral data

The costs for recovery was reduced by 10 million yen and the period was shorten from 1.5 year to 7 months.

In the area where the cadastral survey was completed, the recovery work started immediately because **land boundaries were clear.**

# Effects of Cadastral Survey (2)

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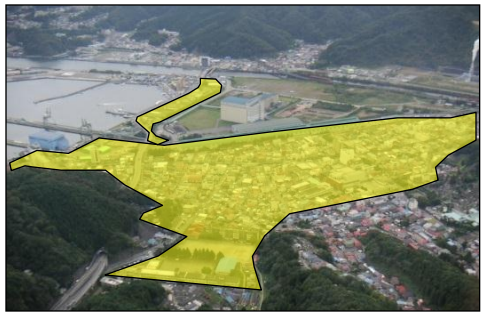
## Reconstruction of center district
-Kamaishi City, Iwate Prefecture-



- Area of 35.1ha
- cadastral survey was completed

### Effect of Cadastral Survey

**With** pre-existing cadastral data

40.9 million yen, 730 days

Saved : 28.1 mil. yen about 12 months

69.0 million yen, 1,100 days (estimation)

**Without** pre-existing cadastral data

The costs for recovery was reduced by 28 million yen and the period was shorten by 12 months.

Pre-existing cadastral data **contributed significantly to early recovery & reconstruction** after the large-scale disaster.

# Effects of Cadastral Survey



When a disaster occurs, boundary features may lost.

If Cadastral Survey data are available

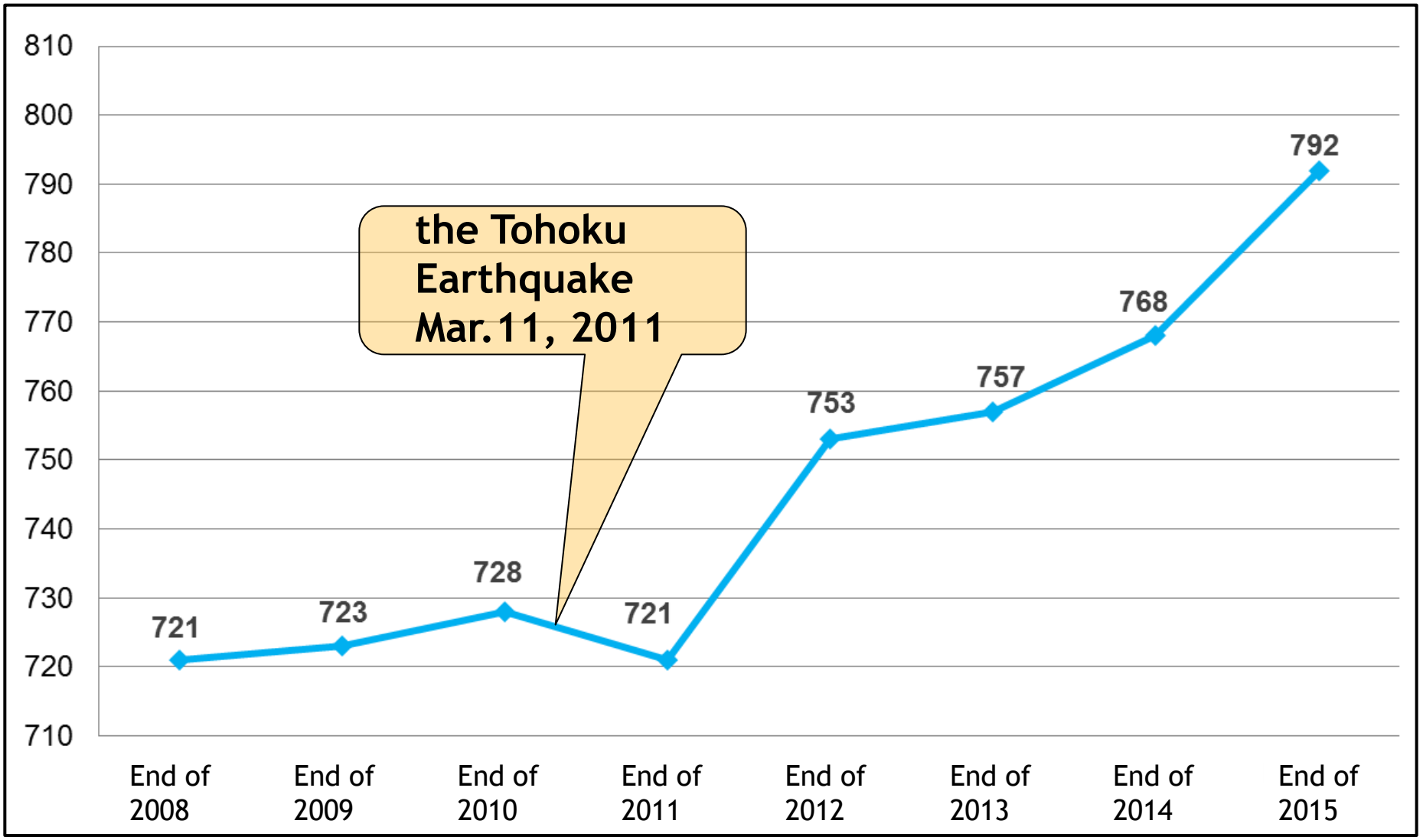
Smooth recovery after natural disaster can be assured

If Cadastral Survey data are **not** available

It will take a long time restore the land boundary to recover the infrastructure and the communities

Pre-existing cadastral data assure smooth recovery after disaster

# No. of municipalities conducting cadastral survey




**Perception changed, cadastral survey promoted**

* The data of end of 2014 and end of 2015 are estimated values

# Significance of Cadastral Survey

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Reduction of trouble concerning land


Smooth Transaction of Interests in Land

Facilitation of public works

**Smooth recovery after natural disaster**

# Summary



2011 Tohoku Earthquake experience shows

- Early revision of control point results
- Pre-existing cadastral data;

are essential for rapid reconstruction process in disaster stricken areas; and

can be considered into land administration being resilient to disasters.