Nov. 26-27, 2012
NERIS WG2 MEETING: EMERGENCY PREPARDENESS AND STAKEHOLDER PARTICIPATION, Oslo, NORWAY

Approaches to Prioritizing Decontamination Strategies on External Radiation Doses in Fukushima

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Working Group on Approaches to Prioritizing Decontamination Strategies on External Radiation Doses in Fukushima
(Tentative Title)

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Our Previous Works

Chemosphere Special Issue,
Volume 53, Issue 4, Pages 277-436 (October 2003)

4th International Workshop on Risk Evaluation and Management of Chemicals

16 Papers

PERGAMON

CHEMOSPHERE

Chemosphere 53 (2003) 389–398

www.elsevier.com/locate/chemosphere

Environmental risk evaluation of chemicals: achievements of the project and seeds for future—development of metrics for evaluating risks

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Received 26 November 2001; received in revised form 21 March 2002; accepted 24 April 2002

Risk Assessment Documents

25 Chemicals
From emission to exposure, hazard, risk
And cost effectiveness

Our Previous Works

Ranking Risks

Risk Factors	Loss of Life Expectnacy (days)
Smoking (All Causes of death)	＞1000
Smoking (lung cancer)	370
Passive Smoking（ischemic heart disease）	120
Diesel Particles (upper bound)	58
Diesel Particles	14
Passive Smoking (lung Cancer)	12
Radon	9.9
Formaldehyde	4.1
Dioxins	1.3
Cadmium	0.87
Arsenic	0.62
Toluene	0.31
Chlorpyrifos (treated houses)	0.29
Benzene	0.16
Methylmercury	0.12
Xylene	0.075
DDTs	0.016
Chlordane	0.009

12 major environmental pollutants in Japan (Gamo et al. 2003)

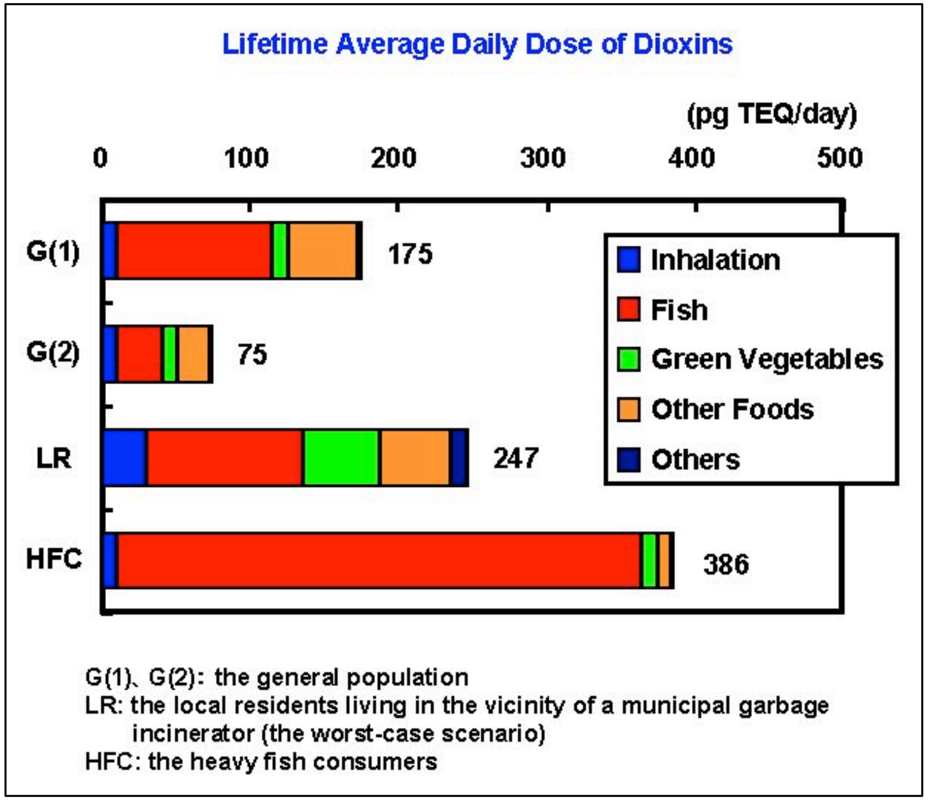
+

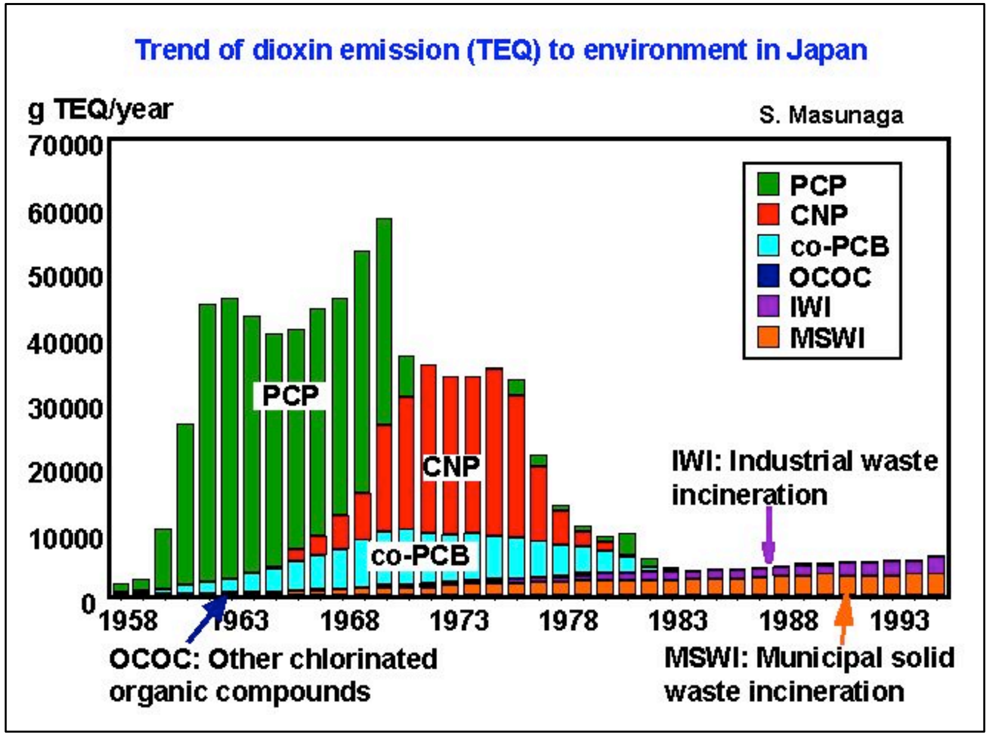
Diesel Particle and Smoking

Adapted from Gamo (2003)

Our Previous Works

Dioxin Risk Assessment





Nakanishi (1999)

Our Previous Works

Cost Effectiveness (Cost per Life Year Saved)

CPLYS (Cost per Life Year Saved) in chemical risk control policies

Oka et al. 2003

Policy programme	CPLYS (million yen)	Sources
prohibition of chlordane	45	Oka et al. (1997)
mercury regulation in caustic soda production	570	Nakanishi et al.(1998)
mercury removal from dry batteries	22	Nakanishi (1995)
regulation of benzene in gasoline	230	Kajihara et al. (1999)
dioxin control (emergency countermeasures)	7.9	Kishimoto et al. (2001)
dioxin control (long-term countermeasures)	150	Kishimoto et al. (2001)
regulation of NOx for automobiles	86	Oka (1996)

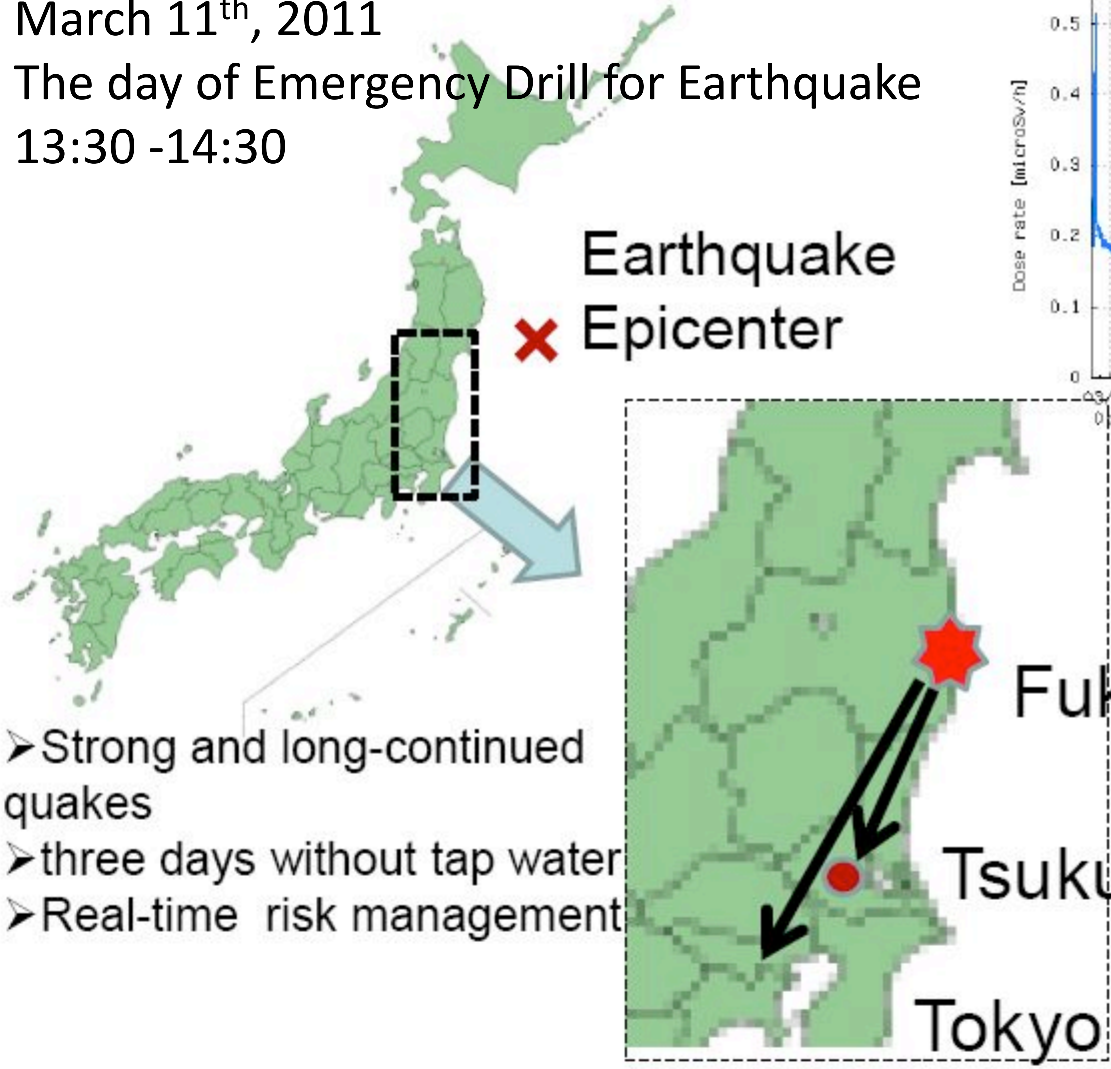
Gamo (2006)

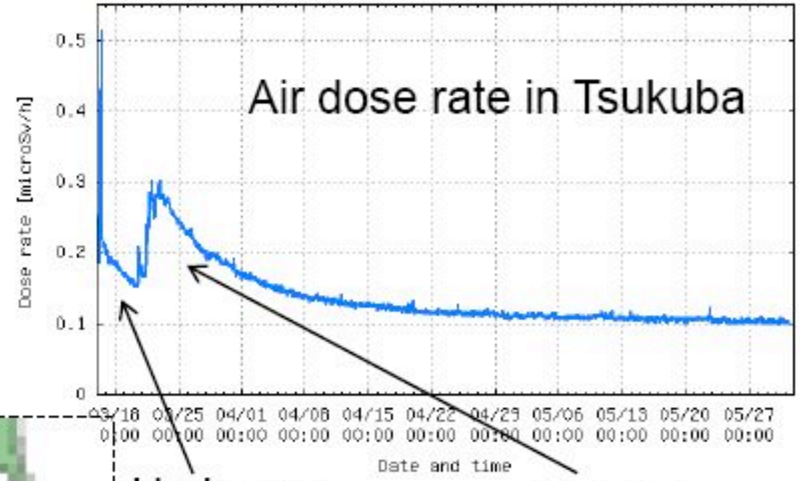
Outline

1. Background and Purpose
2. Cost-Effectiveness Analysis(CEA) of Decontamination Options in Fukushima
3. Incorporation of “Return Ratio” into CEA
4. Summary

Personal experience in March 2011

March 11th, 2011
The day of Emergency Drill for Earthquake
13:30 -14:30



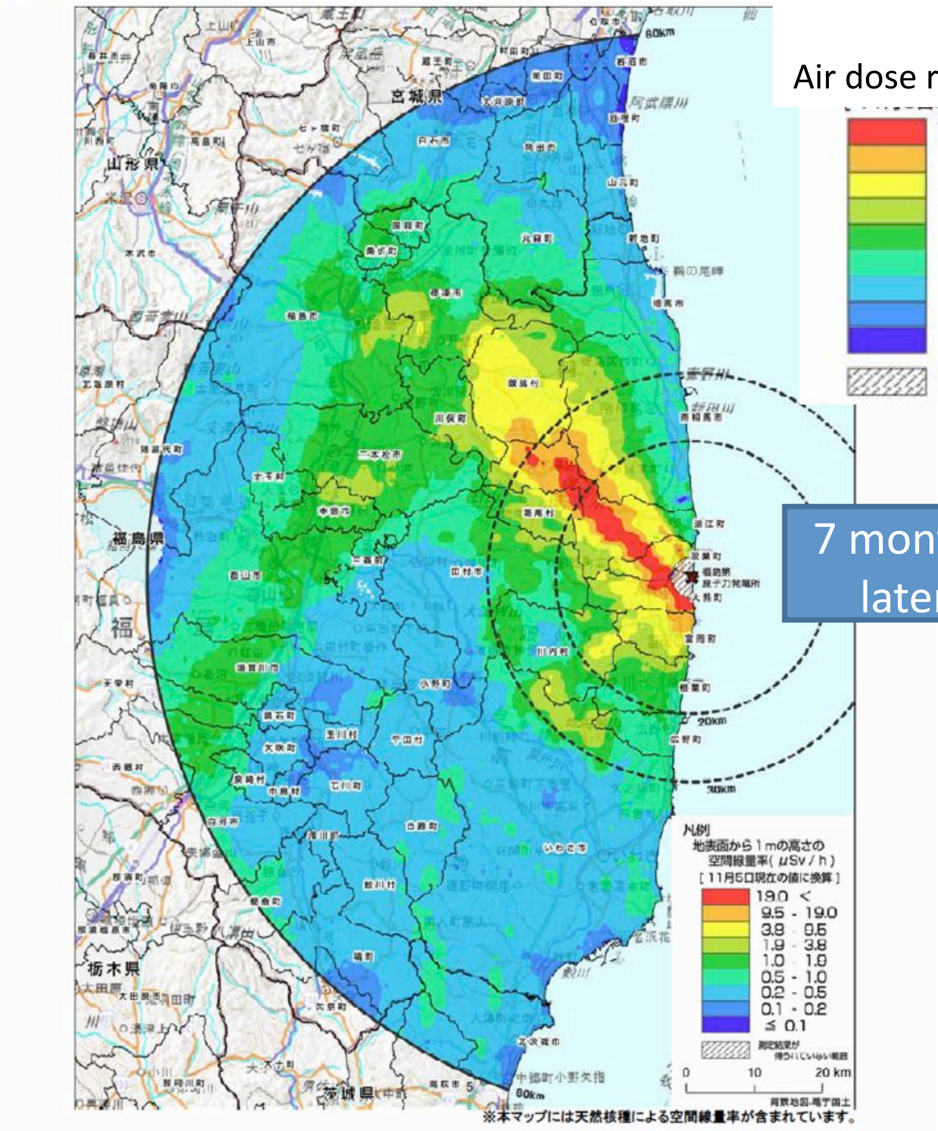


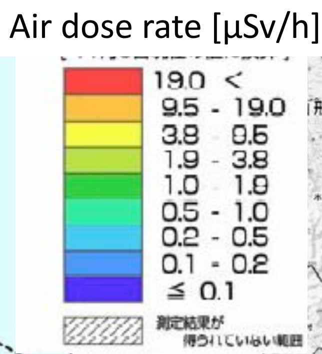
- ➢Strong and long-continued quakes
- ➢three days without tap water
- ➢Real-time risk management

Adapted from Kishimoto (2011)

Radionuclides associated with the accident of FNPP1 spread widely and the high dose rate regions are found in the North-West of the plant.

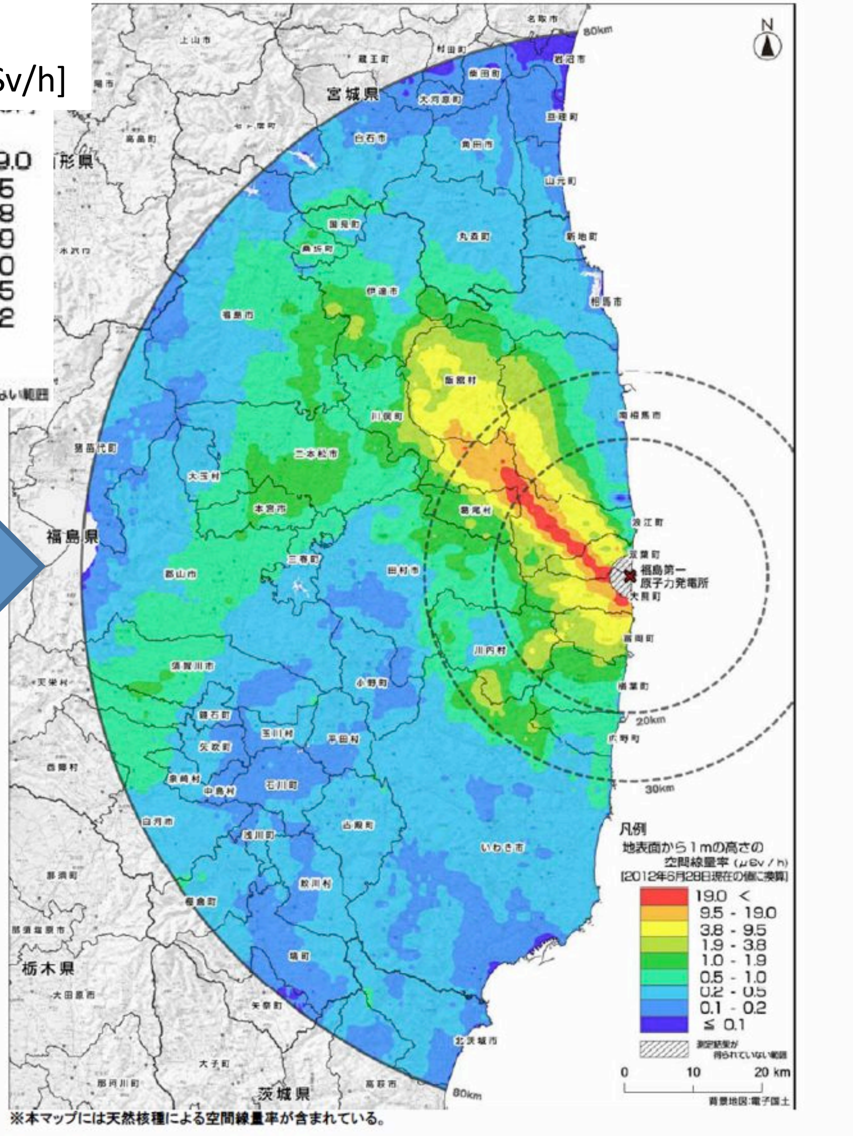
Air dose rate [μSv/h] based on aircraft monitoring survey by MEXT as of Nov.5th , 2011



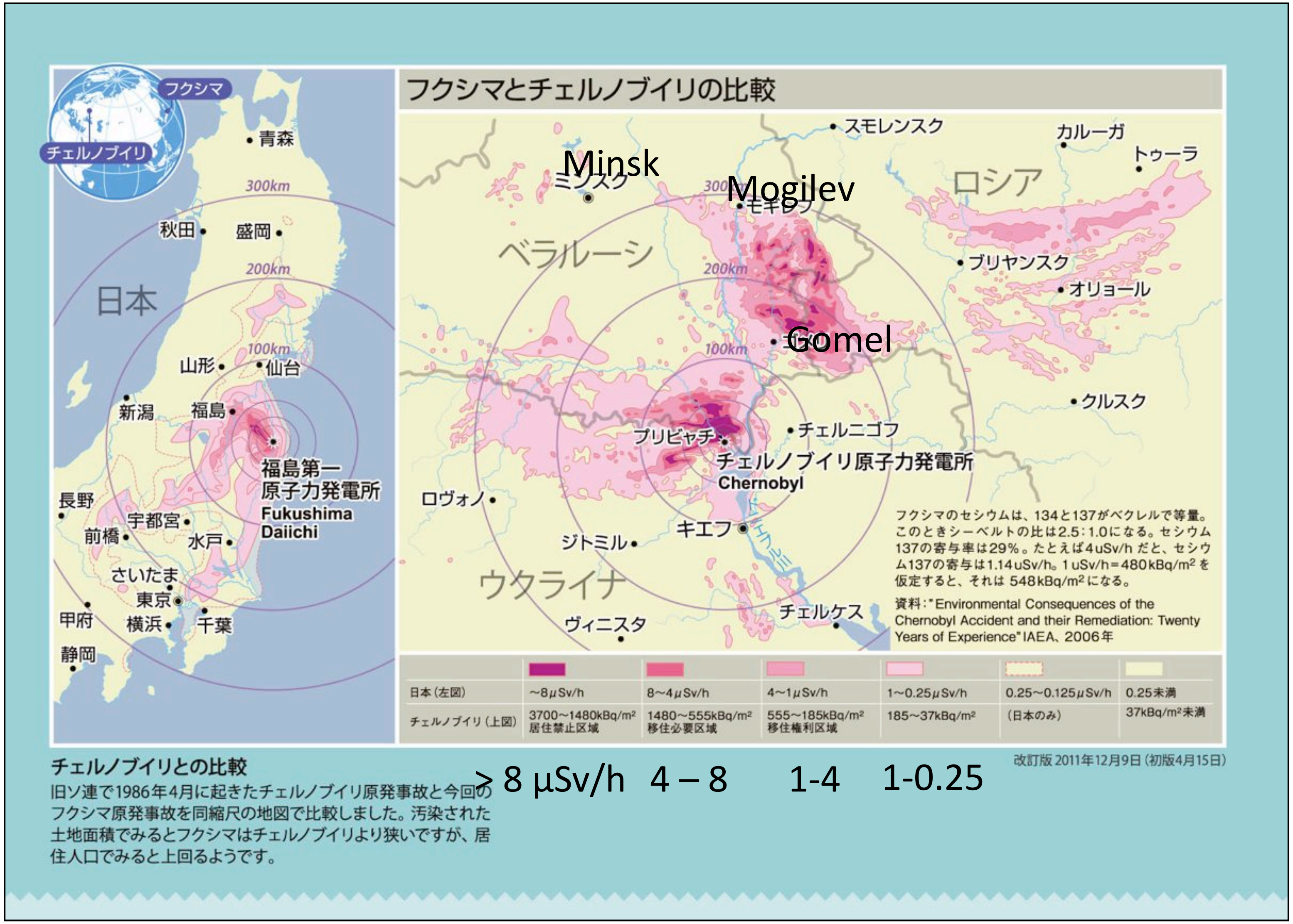


7 months later

June 28th, 2012



Comparison of Fukushima and Chernobyl



Yukio Hayakawa (2012)
http://kipuka.blog70.fc2.com/blog-entry-535.html

Area of Radionuclides Deposition Level

Chernobyl

Contamination Level (kBq/m^2)	Area km^2
37-185	162,160
185-555	19,100
555-1480	7,200
>1480	3,100

Fukushima

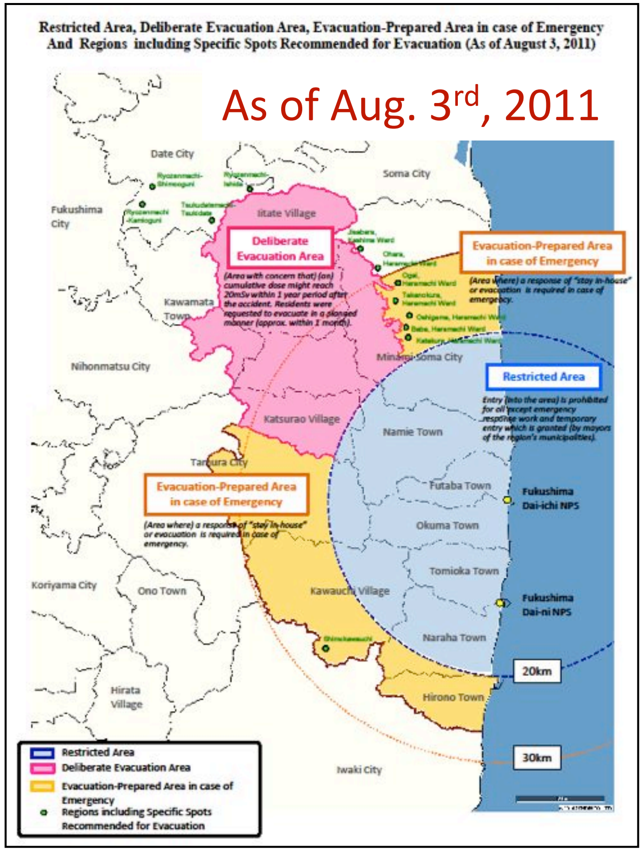
Contamination Level (kBq/m^2)	Area km^2
--------	--------
300-600	500
600-1000	200
1000-3000	400
3000-14,710	200

The evacuation area is contaminating to dose level with a dose of 20 mSv/year and greater.

20 mSv/year ≒3.8 μSv/h ≒993 (kBq/m^2)

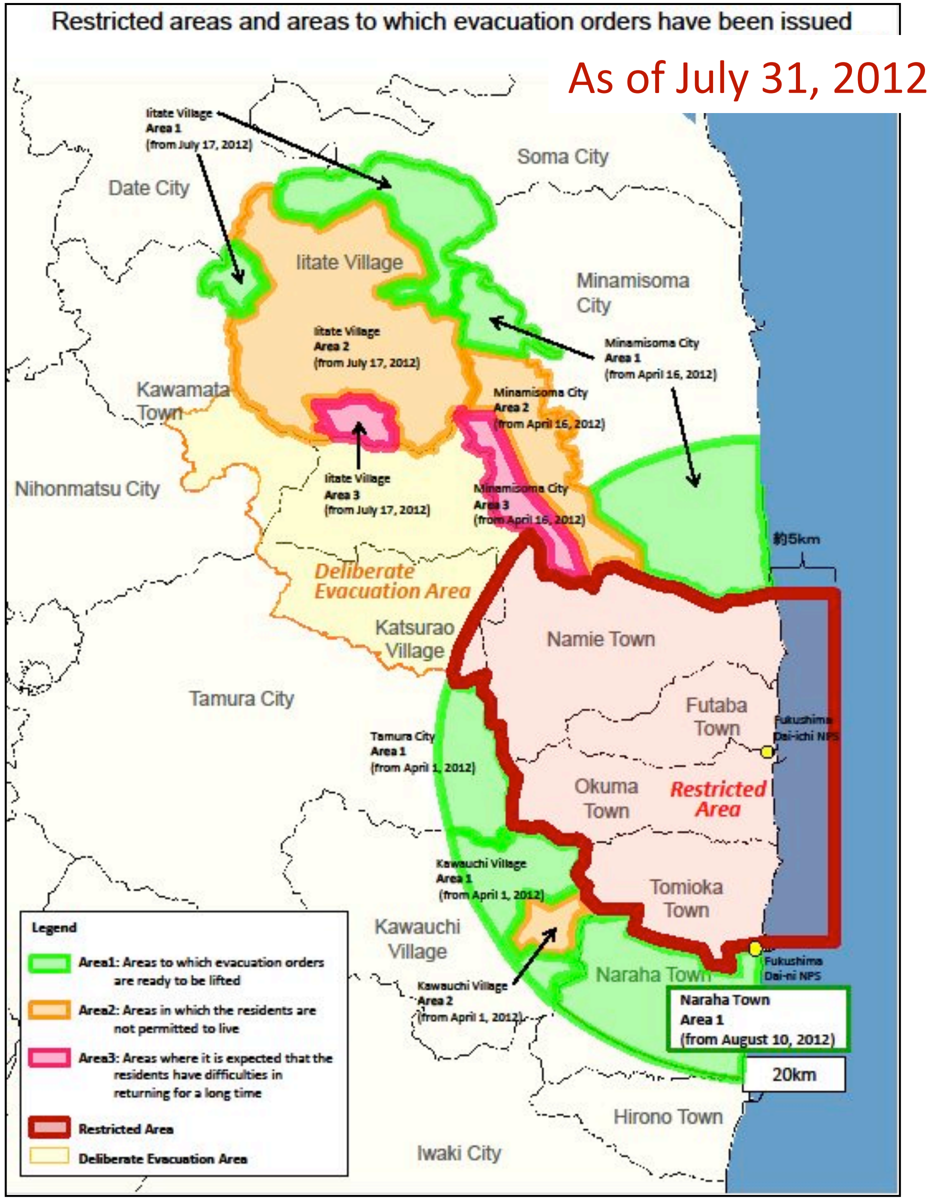
Nakanishi (2012)

Evacuation



http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/20120731_01.pdf

Area	Pop. (thousand)
Restricted Area	77
Deliberate Evacuation Area	10
Emergency Evacuation Preparation Area	59



http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/evacuation_map_a.pdf

Legal Framework

Act on Special Measures concerning the Handling of Radioactive Pollution

Promulgated: at the end of August 2011, Fully came into force: January 1, 2012

Basic Principles of the Act

-Decided by the Cabinet: November 11, 2011

The Order and Ordinance

-Promulgated: December 14, 2011

Decontamination-related regulations:

Standards for decontamination, standards for collection and transfer, storage standards for the removed soil, etc.

Designation of the target areas: December 28, 2011

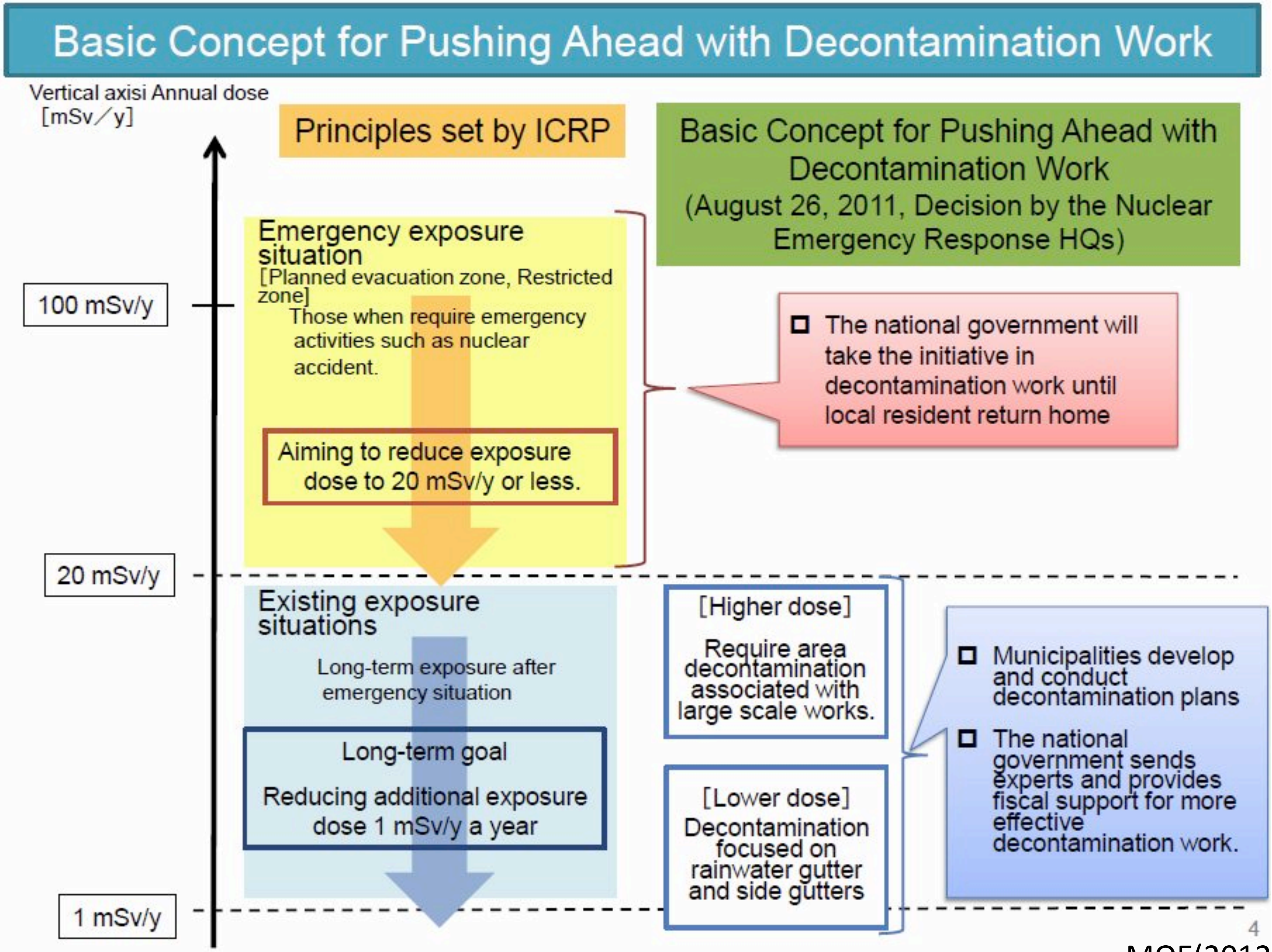
Special Decontamination Areas: 11 municipalities*
(20km radius from NPP + area with 20 mSv of annual cumulative dose)

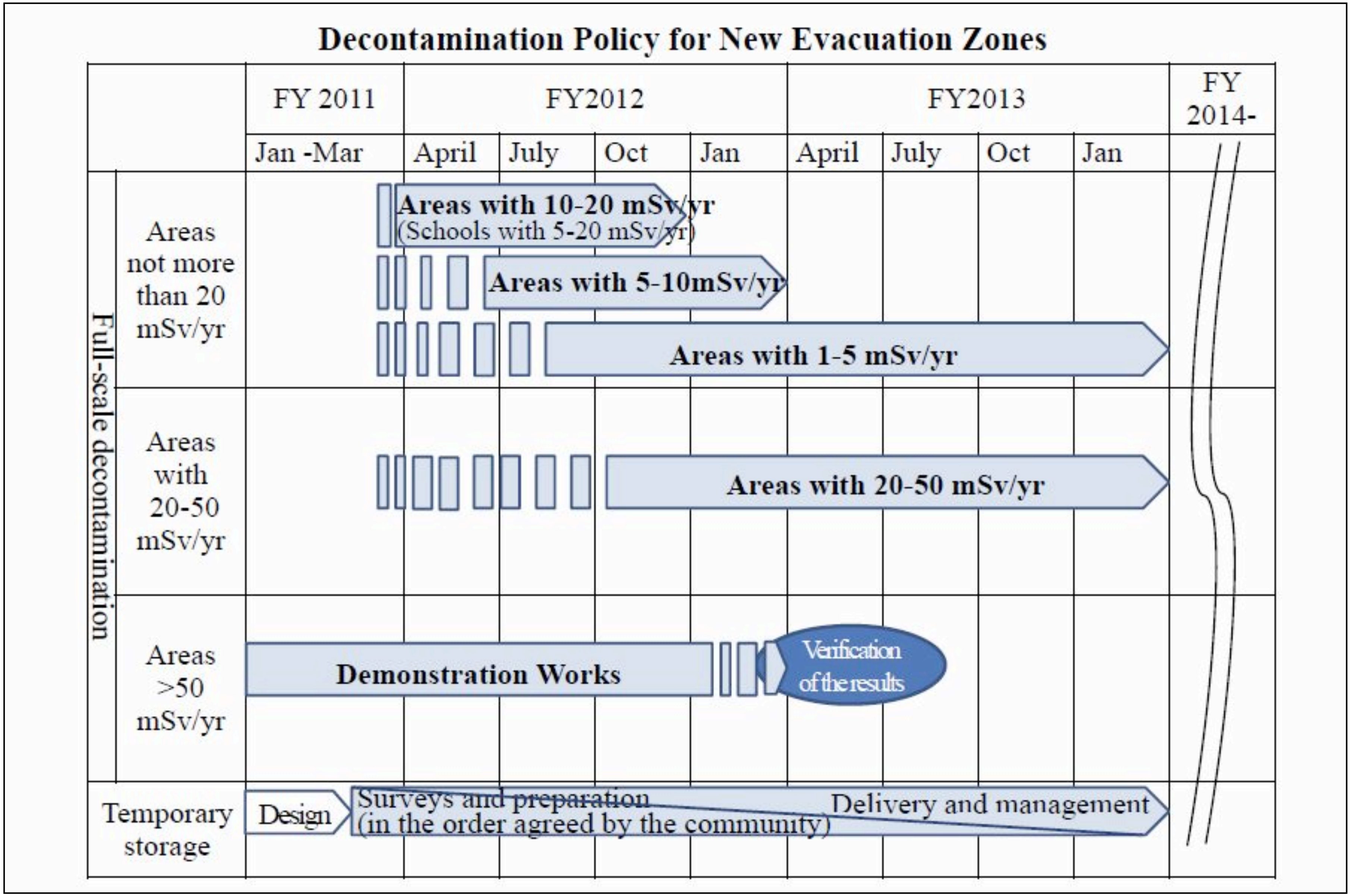
Intensive Contamination Survey Areas:104 municipalities
(area with 1-20 mSv annual cumulative dose)

Waste-related regulations:

Designation standards for Designated Waste, collection and transfer standards, storage standards and final disposal standards for decontaminated waste, etc.

Makiya (2012) Overview of Japan's Offsite Cleanup Efforts
http://www.iges.or.jp/jp/news/event/isap2012/pdf/24/S2-1-2_Makiya.pdf

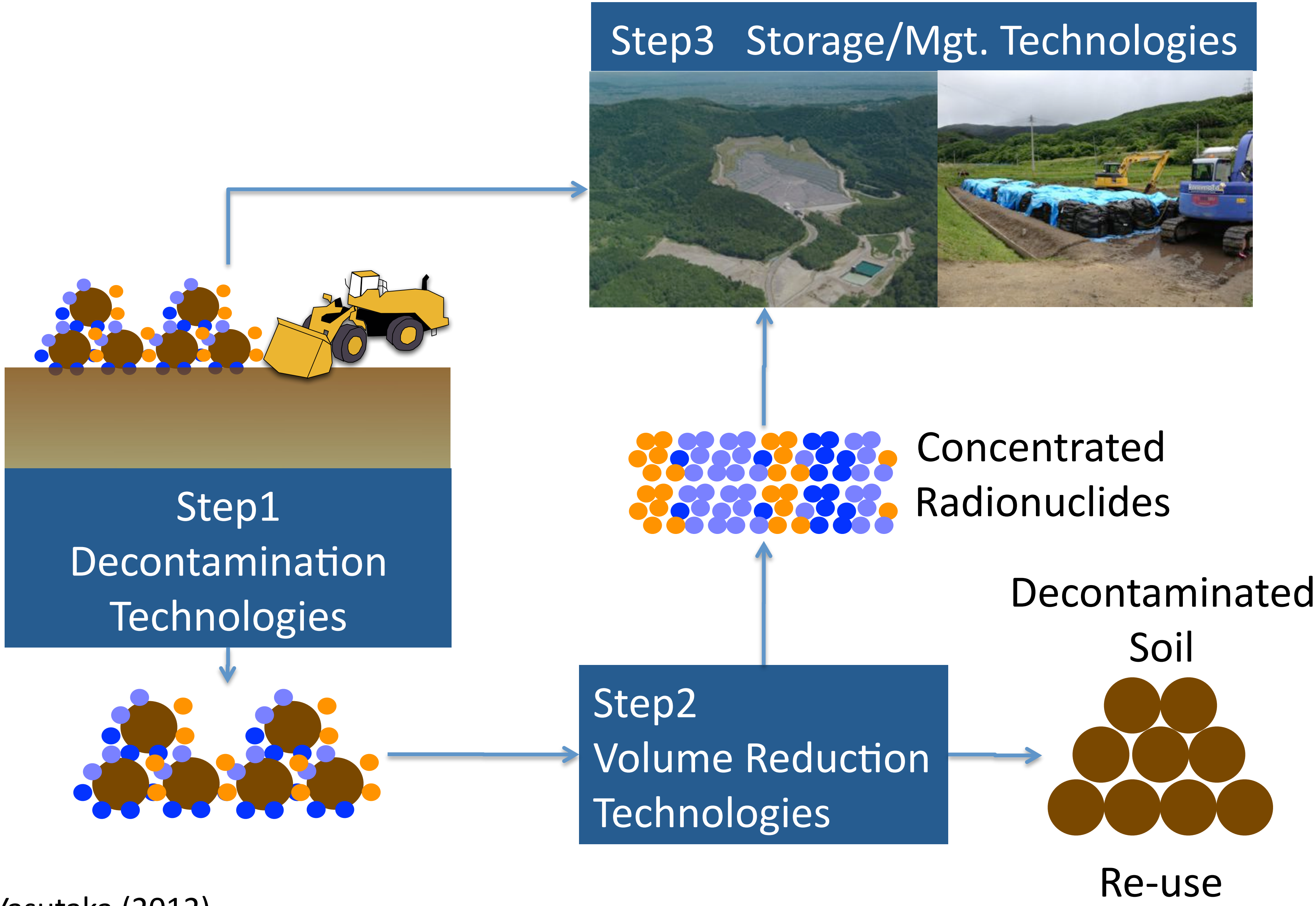

Basic Concept for Pushing Ahead with Decontamination Work
Vertical axisi Annual dose [mSv／y]
Principles set by ICRP
Basic Concept for Pushing Ahead with Decontamination Work (August 26, 2011, Decision by the Nuclear Emergency Response HQs)
100 mSv/y
20 mSv/y
1 mSv/y
Emergency exposure situation
[Planned evacuation zone, Restricted zone]
Those when require emergency activities such as nuclear accident.
Aiming to reduce exposure dose to 20 mSv/y or less.
The national government will take the initiative in decontamination work until local resident return home
Existing exposure situations
Long-term exposure after emergency situation
Long-term goal
Reducing additional exposure dose 1 mSv/y a year
[Higher dose]
Require area decontamination associated with large scale works.
[Lower dose]
Decontamination focused on rainwater gutter and side gutters
Municipalities develop and conduct decontamination plans
The national government sends experts and provides fiscal support for more effective decontamination work.
4
MOE(2012)



Decontamination Policy for New Evacuation Zones
FY 2011
FY2012
FY2013
FY 2014-
Jan -Mar
April
July
Oct
Jan
April
July
Oct
Jan
Full-scale decontamination
Areas not more than 20 mSv/yr
Areas with 10-20 mSv/yr
(Schools with 5-20 mSv/yr)
Areas with 5-10mSv/yr
Areas with 1-5 mSv/yr
Areas with 20-50 mSv/yr
Areas with 20-50 mSv/yr
Areas >50 mSv/yr
Demonstration Works
Verification of the results
Temporary storage
Design
Surveys and preparation
(in the order agreed by the community)
Delivery and management

MOE(2012)

Decontamination Process



Yasutaka (2012)

Decontamination Process

1. **To remove the contaminated soil, stone, and various materials**
2. **To pack the contaminated disposal in the Frecon Pack (Flexible Containers)**
3. **To move the Frecon packs to a tentative-tentative neighbor hood refuge dump and keep them for a while**
4. **To move the Frecon packs from the tentative-tentative refuge dump to a tentative city refuge dump made for radioactive refuge and keep them for 30 years.**
5. **To move them to the final dump**

Nakanishi (2012)

Problems of the ongoing decontamination

Technical problem

Effectiveness of risk reduction is unclear

Limited stockyard spaces for contaminated soil

The dose level attained by the decontamination is much higher than those are acceptable by the residents and the Government has made public commit to attain.

The Government has promised the two goal dose levels:
1) 1mSv/year (final goal), and
2) to reduce doses by 50% by Summer of 2013 .
In Intensive Contamination Survey Areas
How safe is safe enough?

Based on Yasutaka (2012) and Nakanishi (2012)

Problems of the decontamination

Social Problem

Does people really return home after decontamination completed?
-- As for elderly people, Yes, but as for younger with children, No (?). How many of them return?

Decontamination Cost

Huge cost (more than 4 billion Euro/ yr)!? How long ? Who pays the cost?

The Government does not prioritize the areas according to "Effectiveness"

Based on Yasutaka (2012) and Nakanishi (2012)


Decontamination is going on…
▪"Restoring the original state" is the fundamental philosophy
However, …


Evacuation Area
about 30km From F1
1.5μSv/h
Photo by Tetsuo Yasutaka


After Decontamination…….
Dose level was reduced, but what extent?
Photo by Tetsuo Yasutaka

Decontamination is going on..

In-Situ or Temporary Storage → Interim Storage → Final Disposal Site

Photo by Tetsuo Yasutaka

Prioritization for decontamination is necessary, but how?

Our Challenging project

Background and Purpose

- For the implementation of effective and efficient risk reduction measures, we need to set different risk reduction options, and assess risk, cost and effectiveness of each option.

- Even though clean-up (decontamination) costs are enormous, almost no quantitative discussion has been conducted on how much risks would be reduced by different risk reduction options.

- In the radiation problems in Fukushima, it is important to consider social, psychological and ethical aspects of evacuation or resettlement.

The aim of the project is to develop remediation strategies (Prioritization) for radiation contaminated areas Fukushima based on cost-effectiveness analyses including social and psychological aspects of evacuation or resettlement.

Project of prioritization on decontamination based on cost-effectiveness analysis

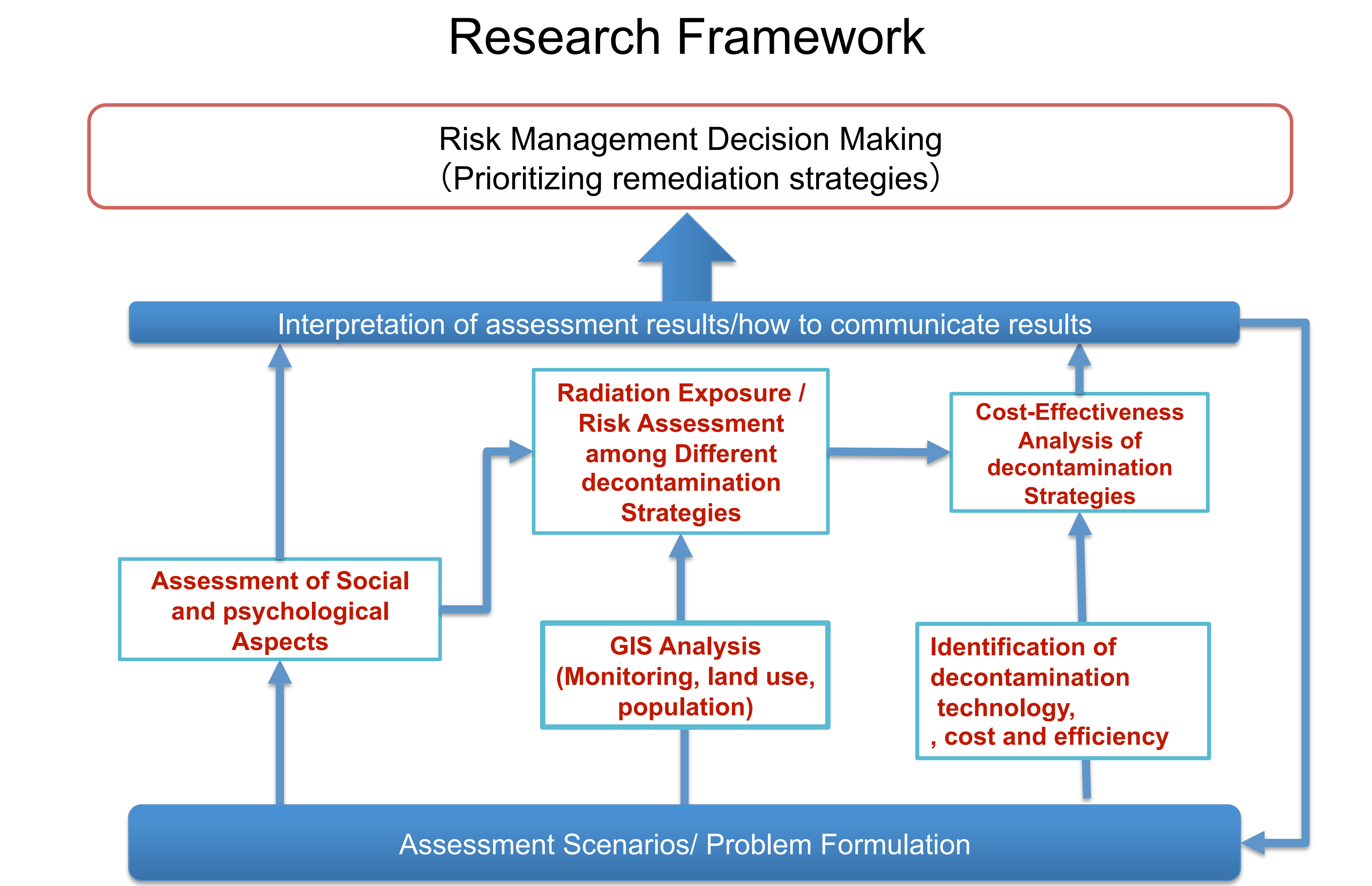
Research steps including

1) Estimation of dose (and risk) reduction, using site-specific land use/soil property and population data

2) Estimation of costs, using realistic unit costs corresponding to several decontamination options

3) Evaluation of happiness on resettlement or return home, comparing to previous case studies e.g. evacuation on air pollution due to volcano explosion

Nakanishi (2012)


Research Framework
Risk Management Decision Making
(Prioritizing remediation strategies)
Interpretation of assessment results/how to communicate results
Radiation Exposure / Risk Assessment among Different decontamination Strategies
Cost-Effectiveness Analysis of decontamination Strategies
Assessment of Social and psychological Aspects
GIS Analysis (Monitoring, land use, population)
Identification of decontamination technology, , cost and efficiency
Assessment Scenarios/ Problem Formulation

Our three potential approaches

- First: The ΔB greater, the more preferable;

  $\Delta B = \{R(\text{contaminated}) - R(\text{Decontaminated})\} \times \{\text{People returning}\}/\text{Cost}$

- Second : The greater ΔB is, the more preferable;

  $\Delta B = \{(\text{Benefit of returning home}) - \Delta R(\text{Increase in risk associated returning home})*\} \times (\text{People returning})/(\text{Cost})$

- Third: Under the premise that the dose for life span should not exceed 100mSv/for approx. 10 to 20 years , the greater ΔB is, the more preferable.

  $\Delta B = (\text{People returning})/(\text{Cost})$

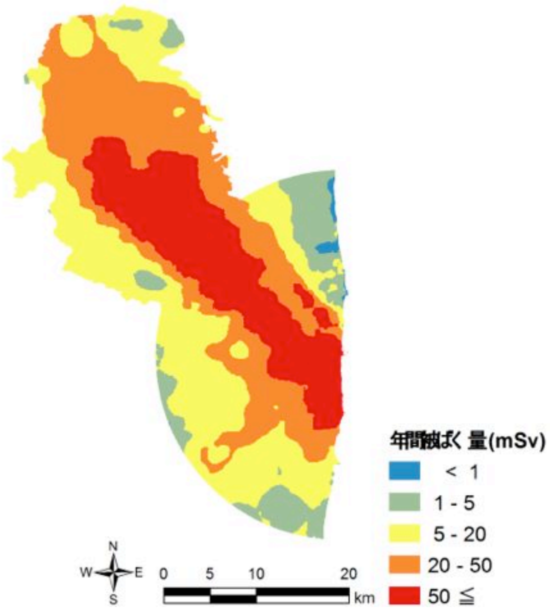
Nakanishi (2012)

R: Human health risk (mainly cancer risk)

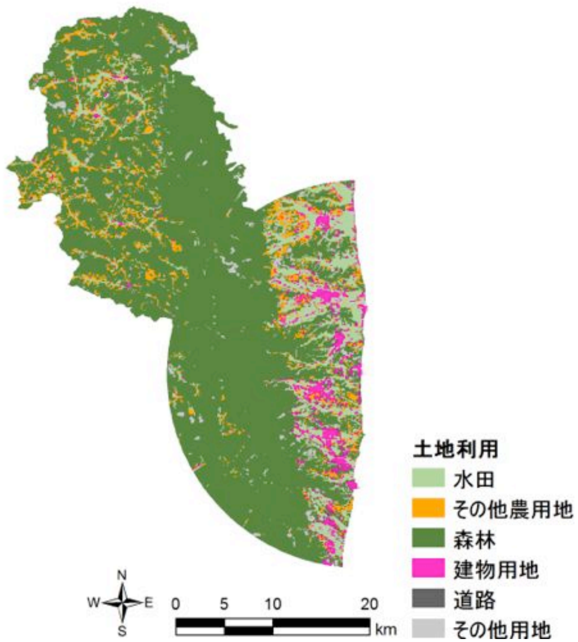
Tentative Results

Please Do not Distribute

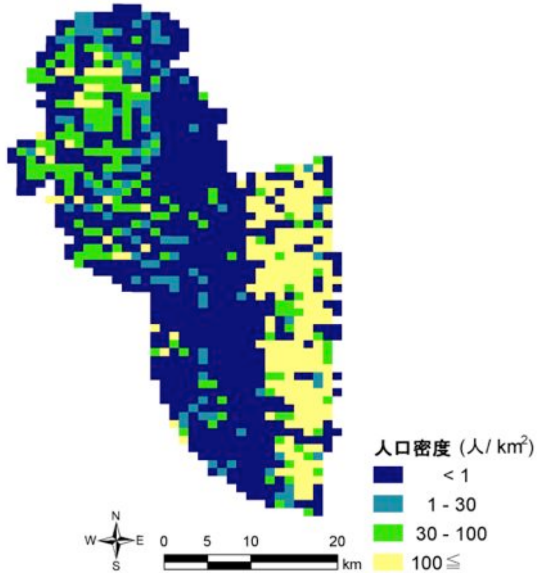
GIS data



Air Dose Rate
MEXT (2011), METI(2012)



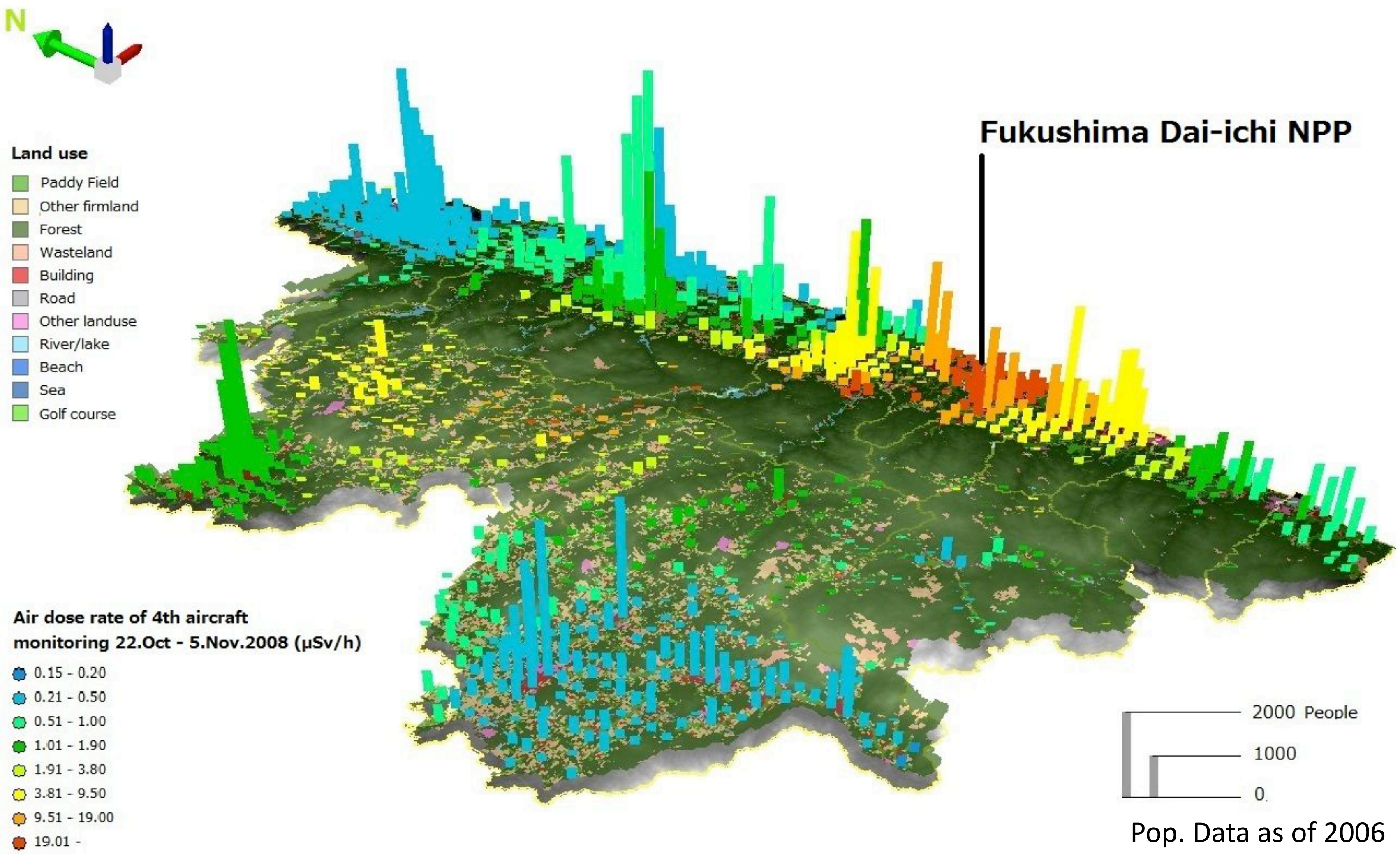
Land Use Data
MLIT(2009)



Population Density
MLIT(2005)

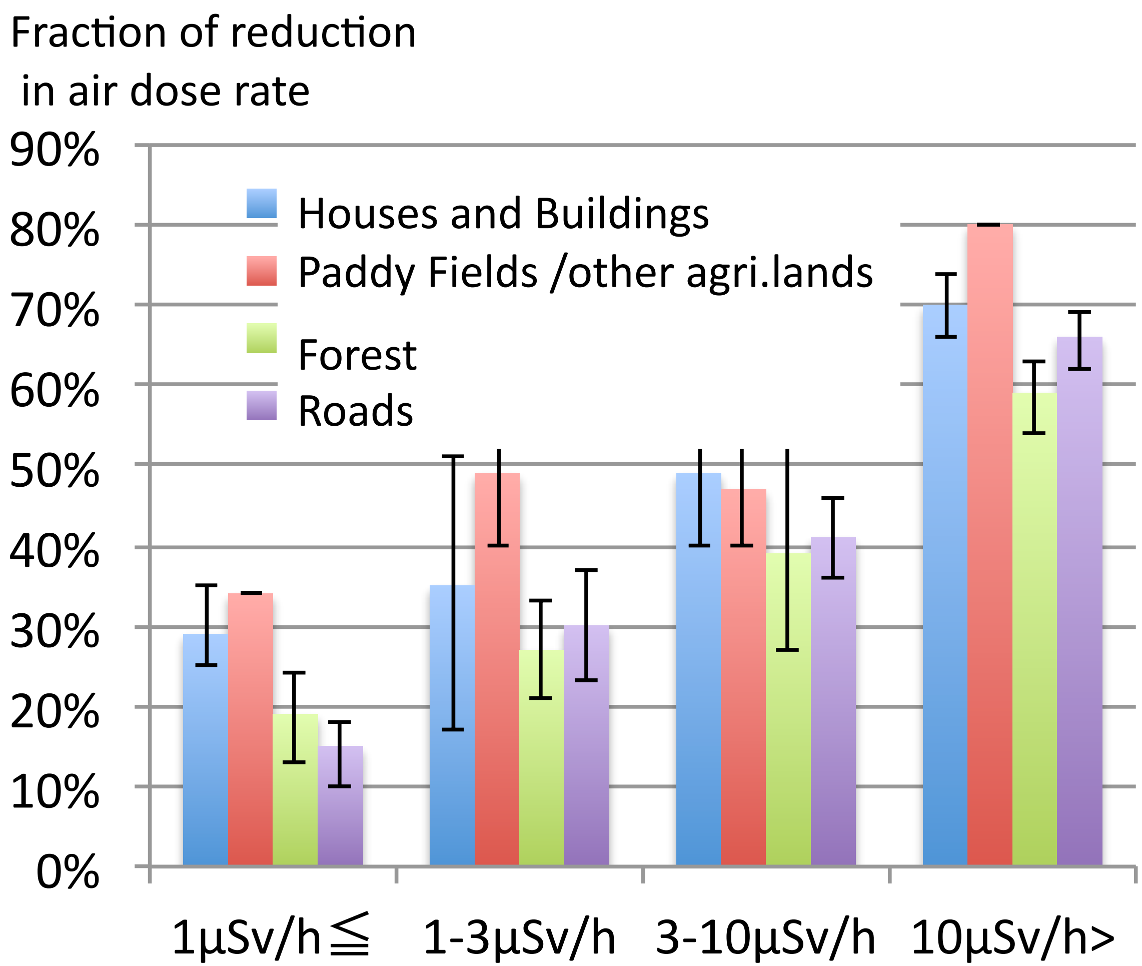
Yasutaka et al. (2012)

Air Dose Rate and Population Density in the affected area in Fukushima



Efficiency of Decontamination

Efficiency of decontamination increases as air dose rates increase



Original Data from JAEA（2012) Report

Decontamination options

Houses and Buildings
high-presser washing and brushing, cleaning gutter, topsoil removal and vegetation removal at yard.

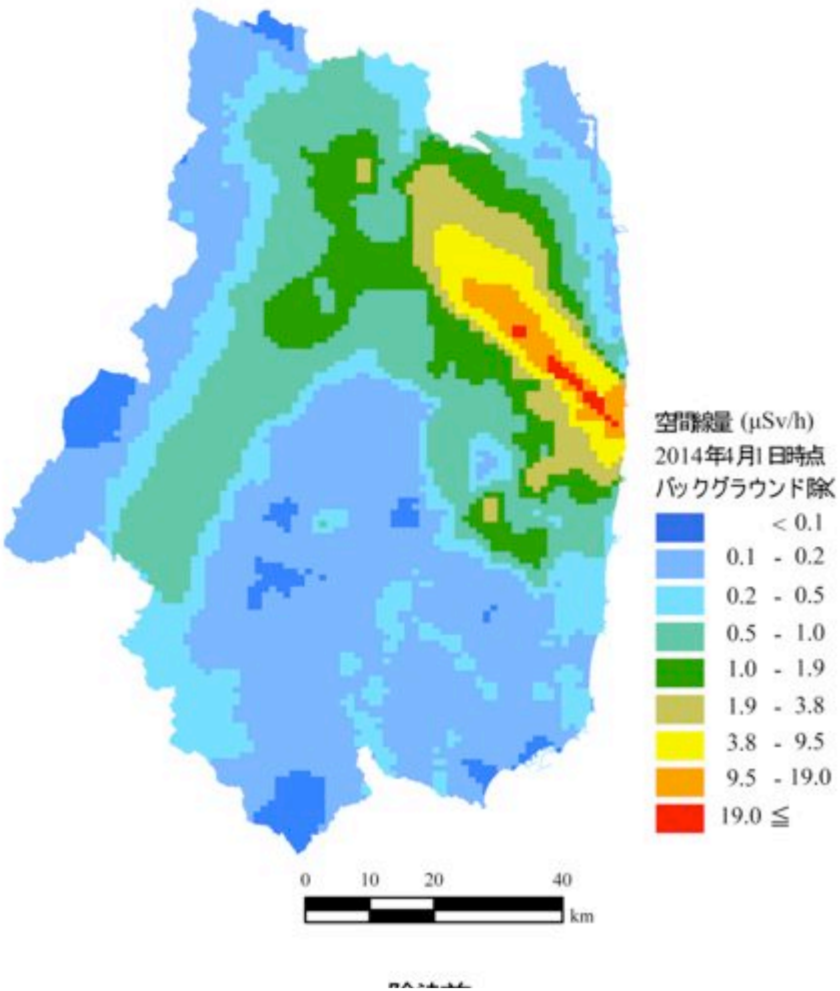
Paddy Fields/Agri.lands
topsoil removal

Forest
Remove fallen leaves and litter layer of 20% area of each 100m-mesh

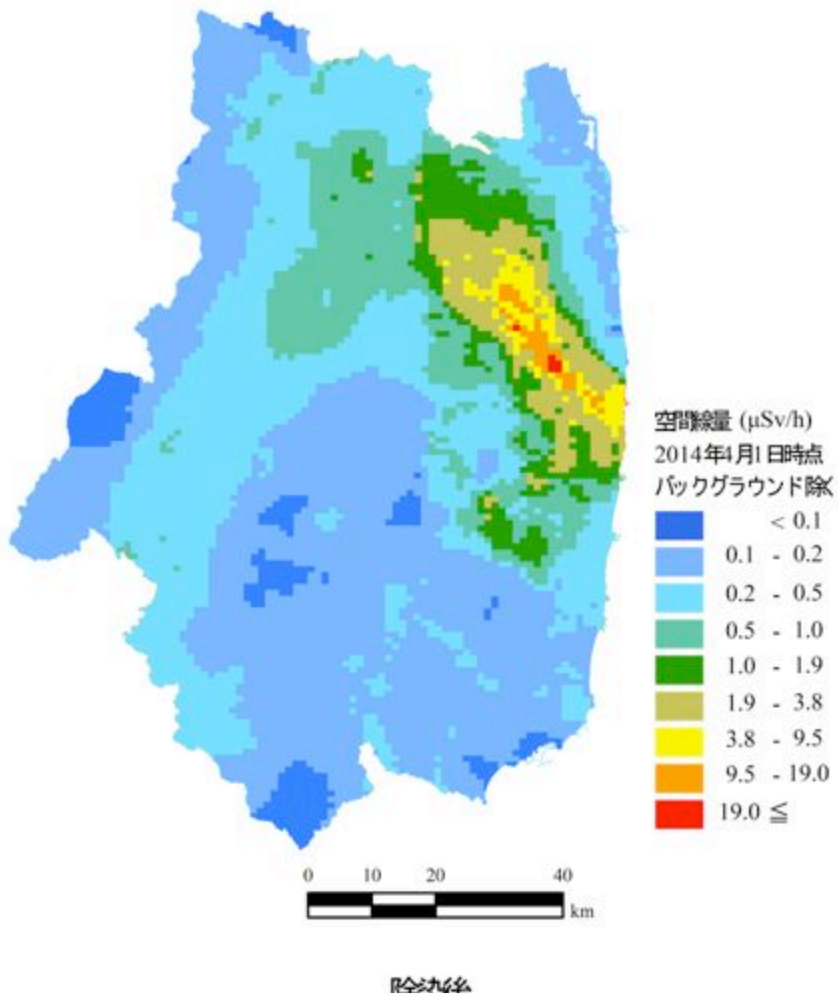
Roads
high-pressure washing or shot-blasting, clean gutters

Yasutaka et al. (In Preparation)

Differences in air dose rate between with or without decontamination



Without Decontamination
Prospective air dose rate as of Apr. 1st, 2014

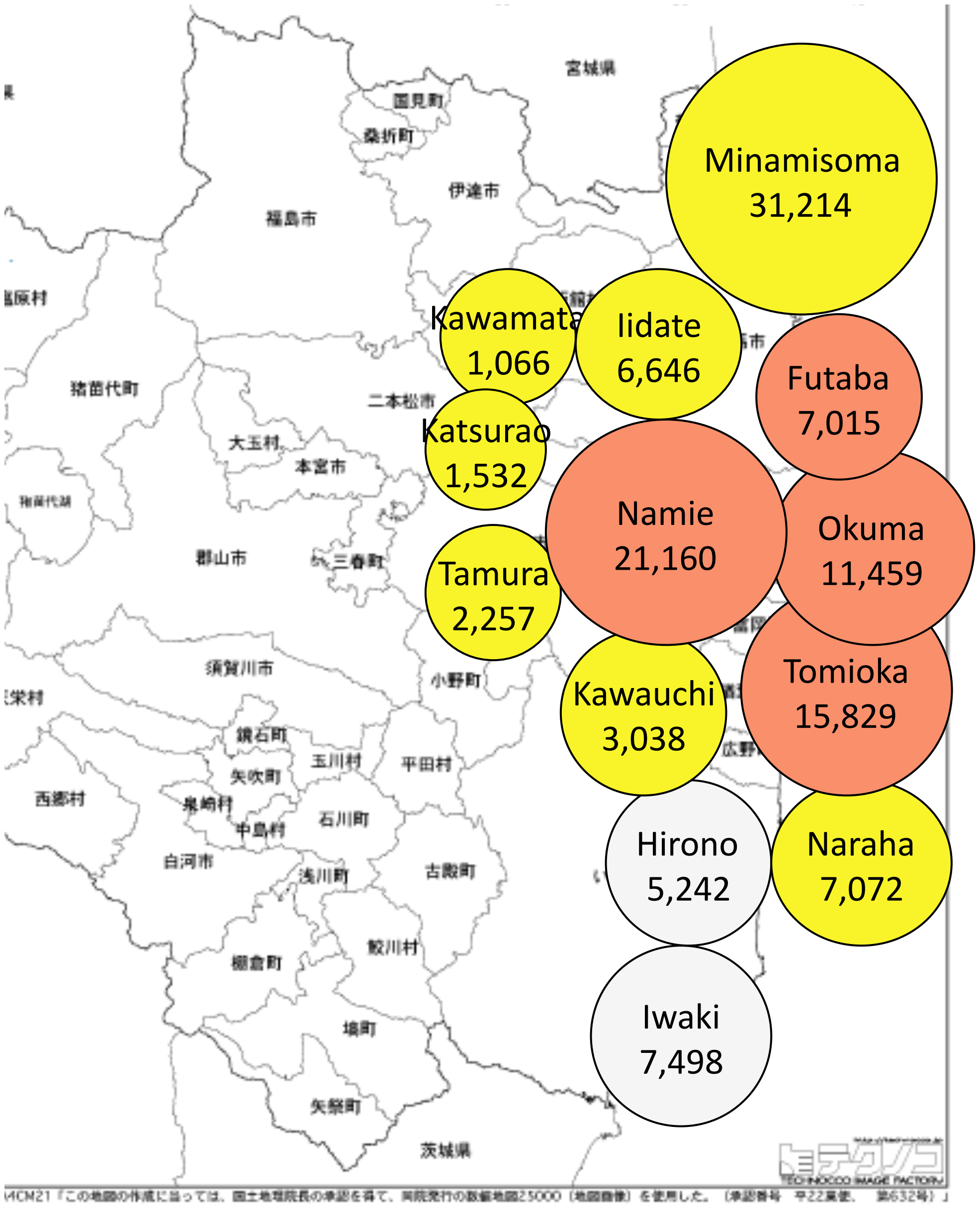


With Decontamination
Prospective air dose rate as of Apr. 1st, 2014

Yasutaka et al. (In Preparation)

Concept of Return Ratio

Number of Evacuees (2012.Feb.12)



※Value in the circle represents population

Municipalities including Restricted Area

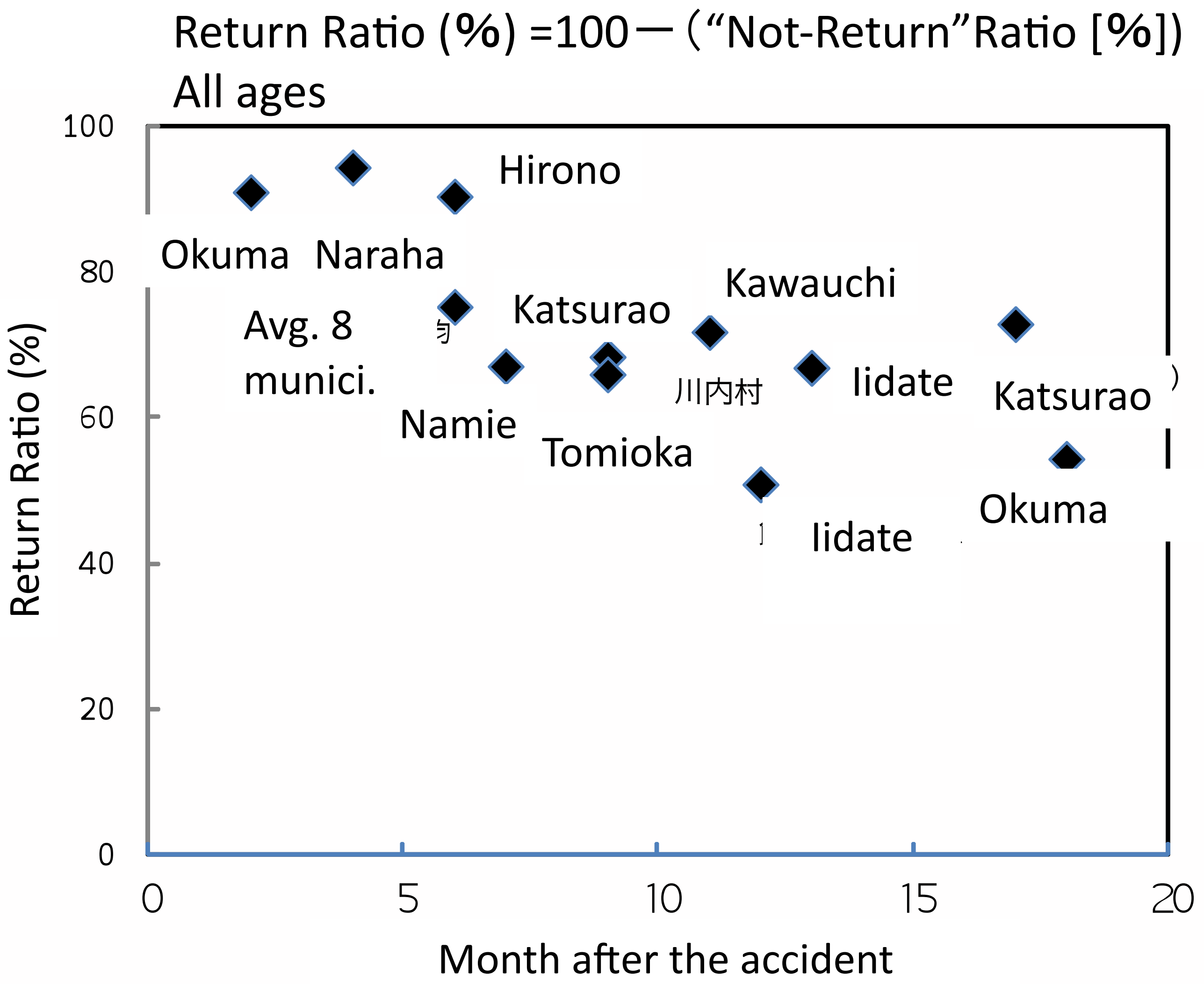
Municipalities including Planned Evacuation Area (As of 2012 Aug.)

ふくしま連携復興センター

ふくしま連携復興センターのデータ
http://f-renpuku.org/wp-content/uploads / 2012/03/1202kengai_hinan.pdf
を小野が加工

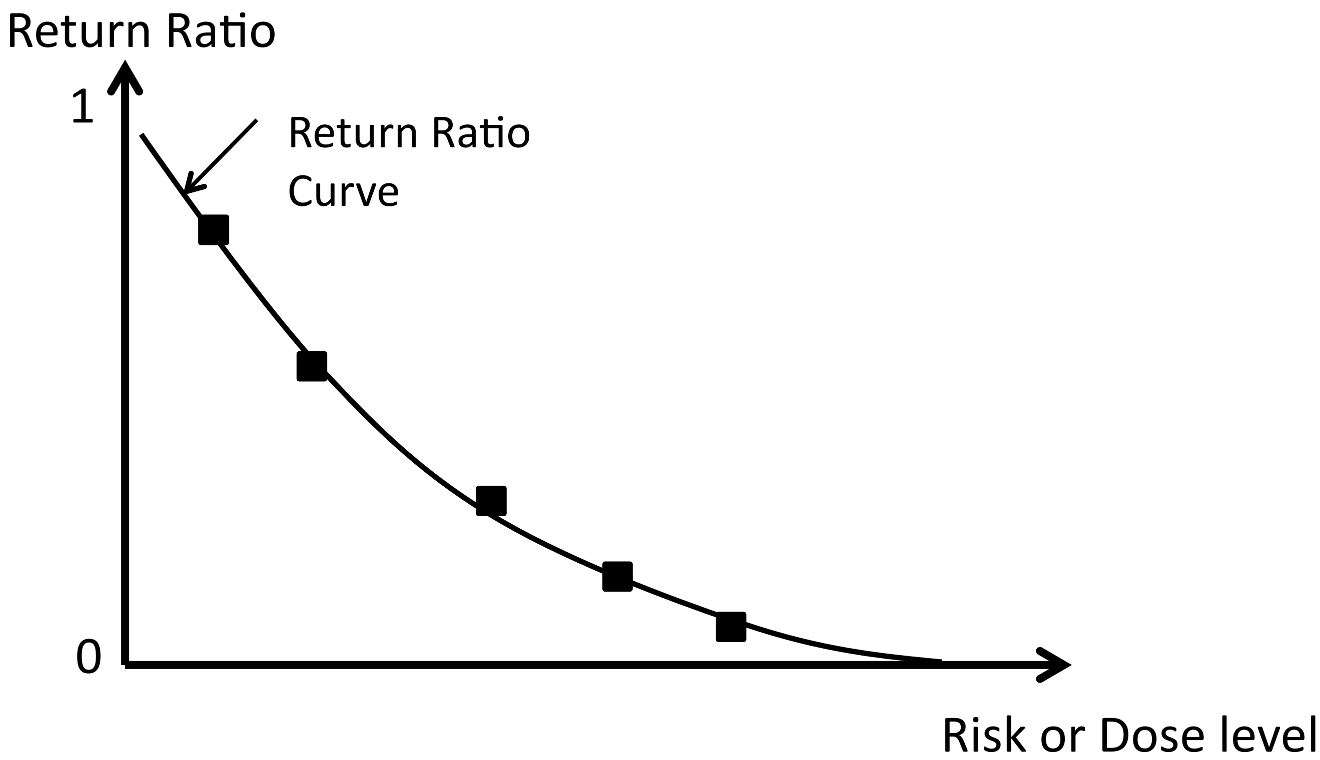
Adapted from Ono (2012)

Return Ratio based on Questionnaire surveys of the municipalities in the affected areas



Adapted from Ono (2012)

Concept of Return Ratio



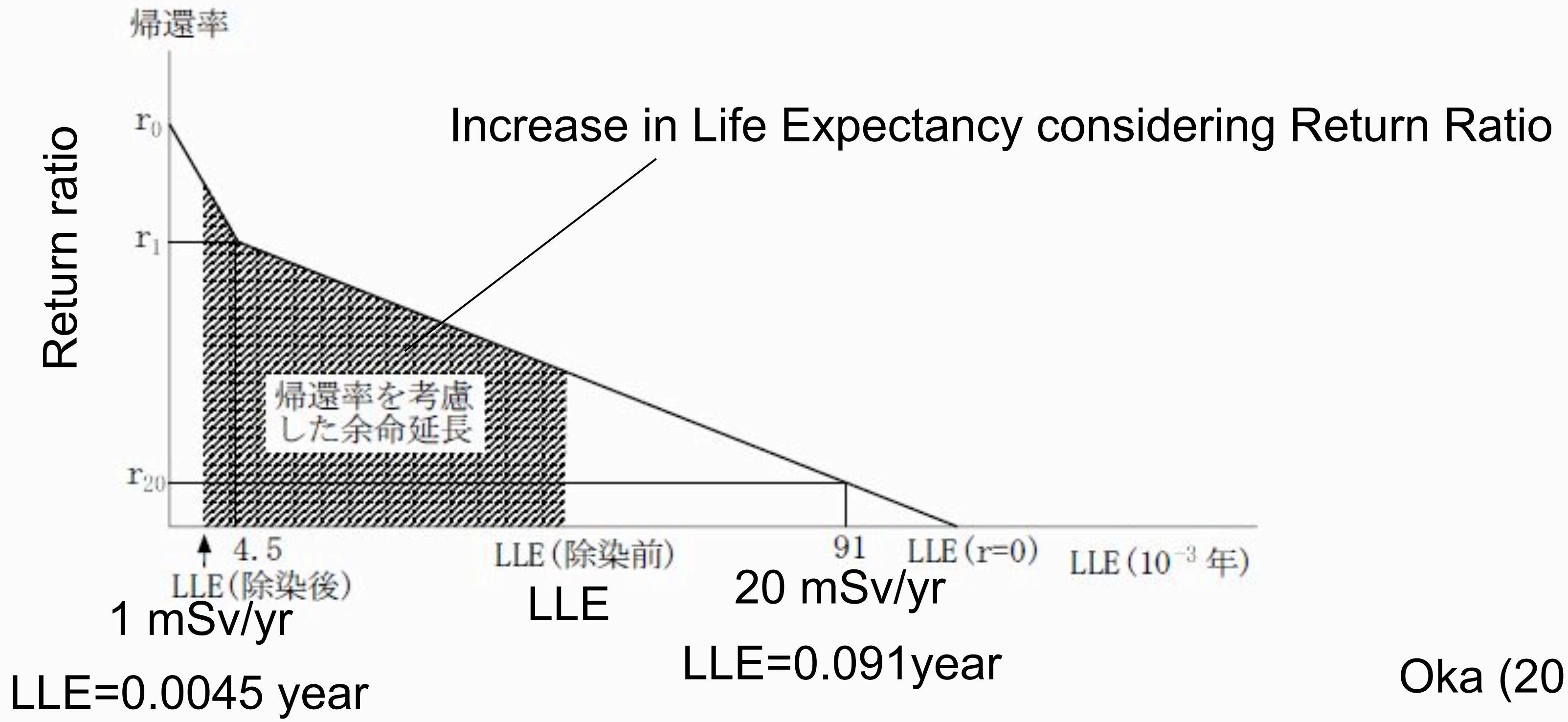
Preference of returning home of individuals (Return Ratio)
for risk or dose level after decontamination

Adapted from Ono (2012)

Return　Ratio　（Tentative）

- Return ratio and Loss of Life Expectancy (LLE)　based on a questionnaire survey in Futaba area in Fukushima
  - ✓ LLE increase →　Return ratio decrease

帰還率を考慮した余命延長



Oka (2012)

Summary

Quantifying risks and cost-effectiveness of decontamination strategies provide a common platform to discuss how we (stakeholders) deal with the problems related to the decontamination in the affected areas in Fukushima.

The effectiveness of decontamination varies depending on the method, land-use and air dose rate.

The concept of “return ratio” is incorporated into the cost-effective analysis of decontamination measures.

Reduction factor (Shielding/Occupancy Factor) , “return ratio” , air dose rate and population density can be important factors affecting the prioritization of decontamination strategies.

Thank you for your attention