Jan. 26, 2021

Asian Disaster Reduction Center Online Tsunami Seminar

Community Space Design for Tsunami Disaster Risk Reduction

1, Space factor for CBDRR

2, Time factor for CBDRR

3, Measure the evacuation speed of vulnerable people

4, Apply to other places and predictions for zoning

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Agenda

1, Space factor for CBDRR

2, Time factor for CBDRR

3, Measure the evacuation speed of vulnerable people

-on experiment courses

-on actual evacuation routes in a community

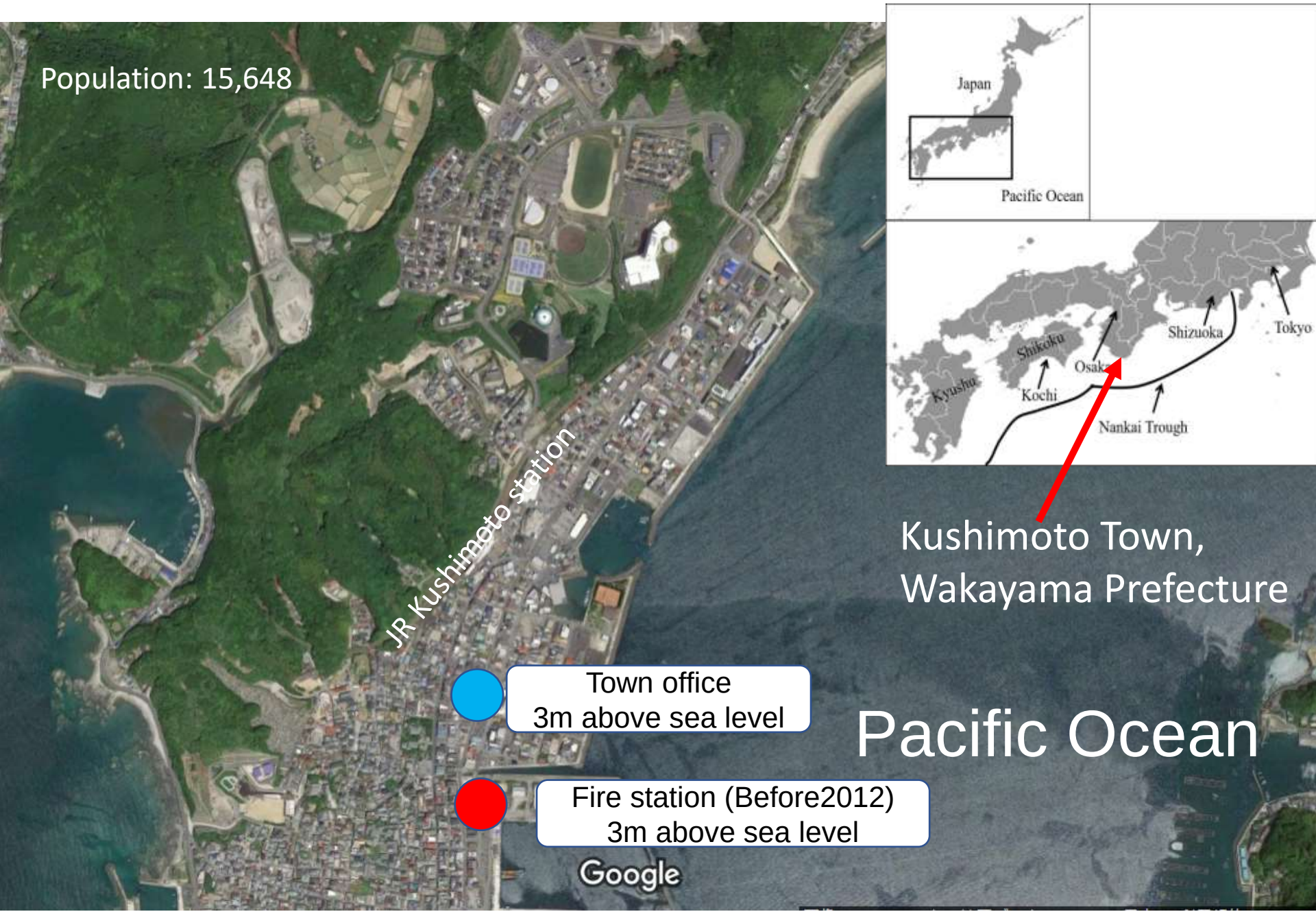
4, Apply to other places and predictions for zoning

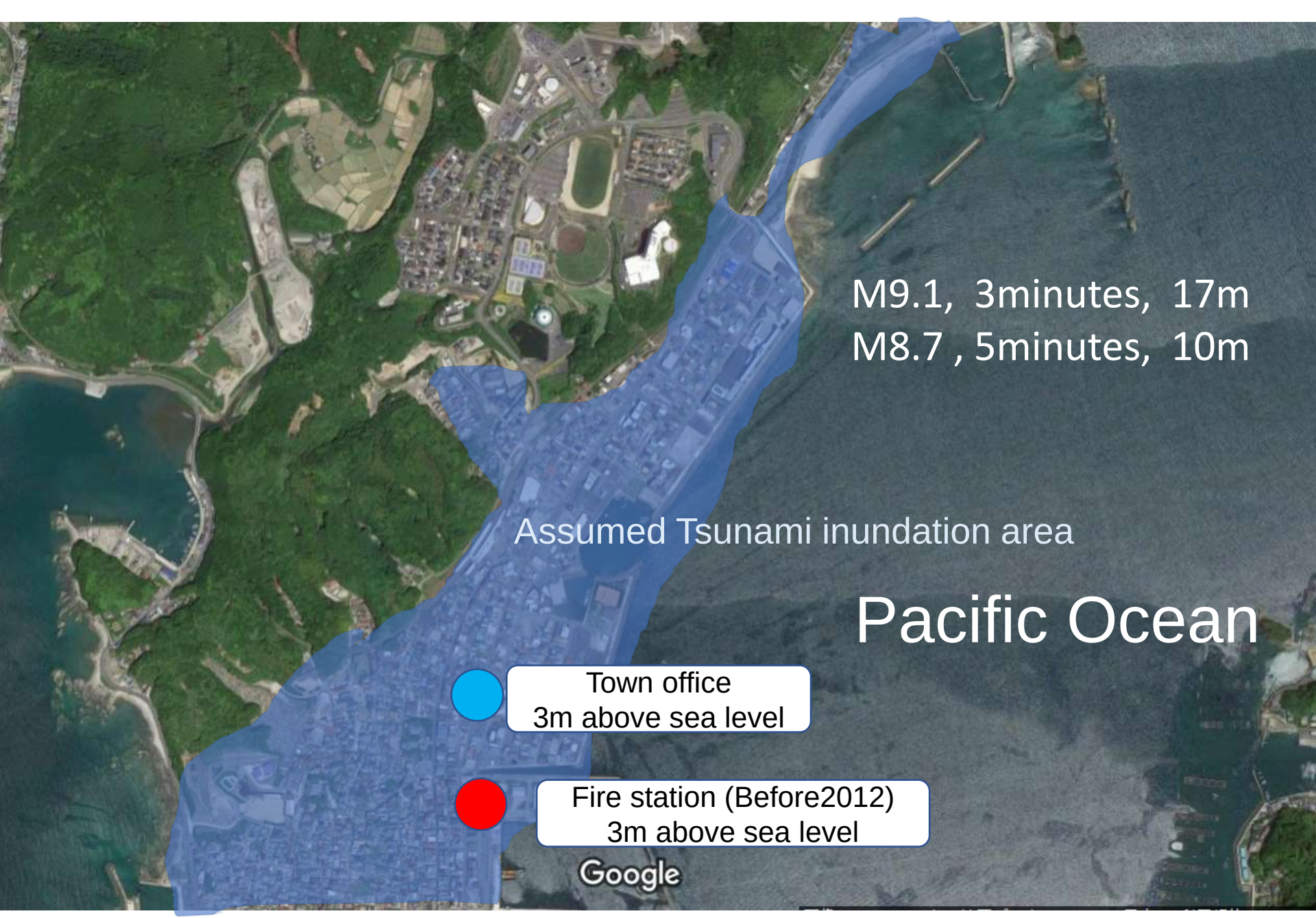
The purpose of this presentation

-To understand that safer space design reduces the necessity of evacuation

-To understand one of the methods to measure and predict evacuation speed

-To adjust today's topics to your target areas or fields


Population: 15,648
Japan
Pacific Ocean
Shikoku
Osaka
Shizuoka
Tokyo
Kyushu
Kochi
Nankai Trough
Kushimoto Town,
Wakayama Prefecture
JR Kushimoto station
Town office
3m above sea level
Fire station (Before2012)
3m above sea level
Pacific Ocean
Google


M9.1, 3minutes, 17m
M8.7 , 5minutes, 10m
Assumed Tsunami inundation area
Pacific Ocean
Town office
3m above sea level
Fire station (Before2012)
3m above sea level
Google

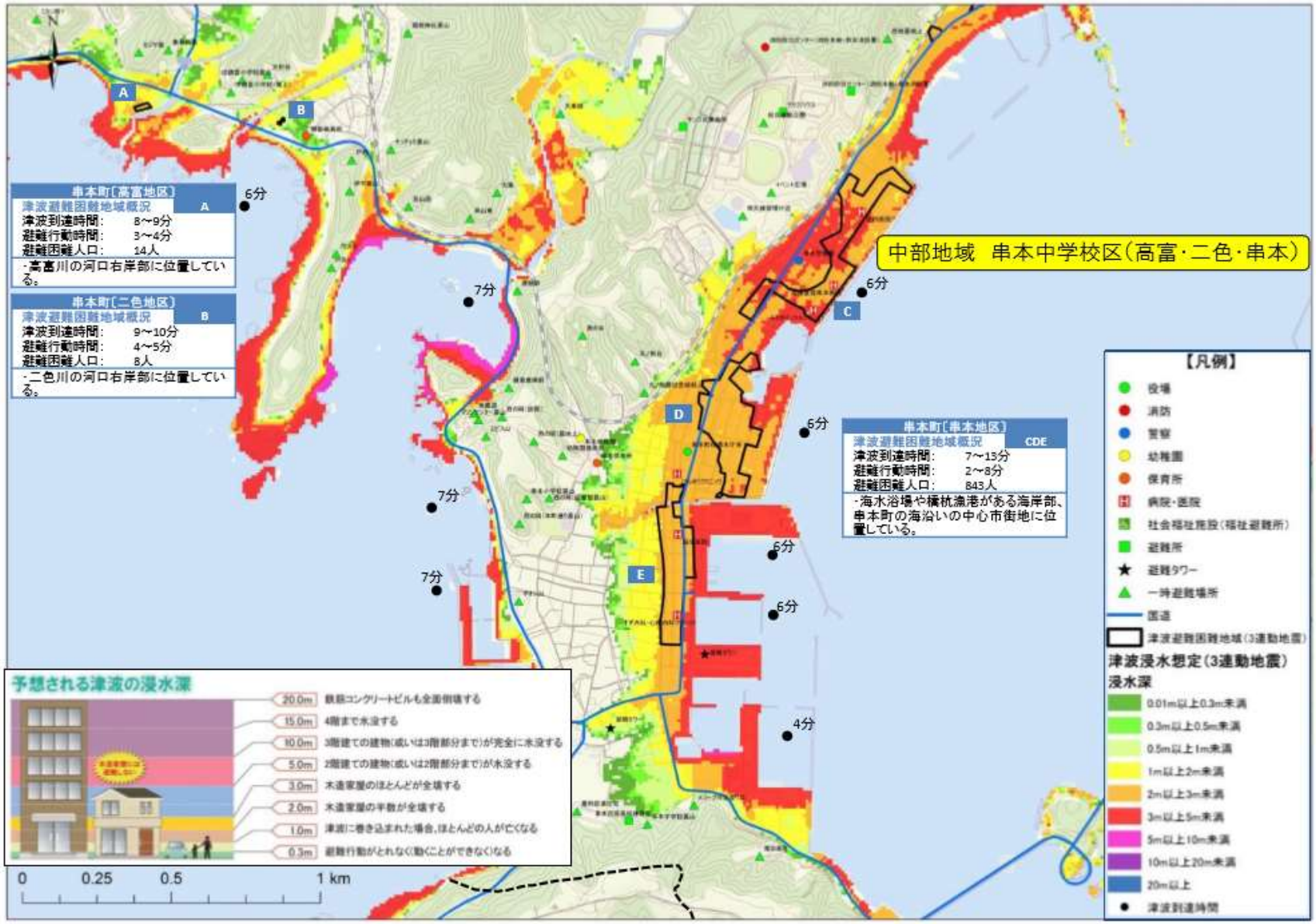
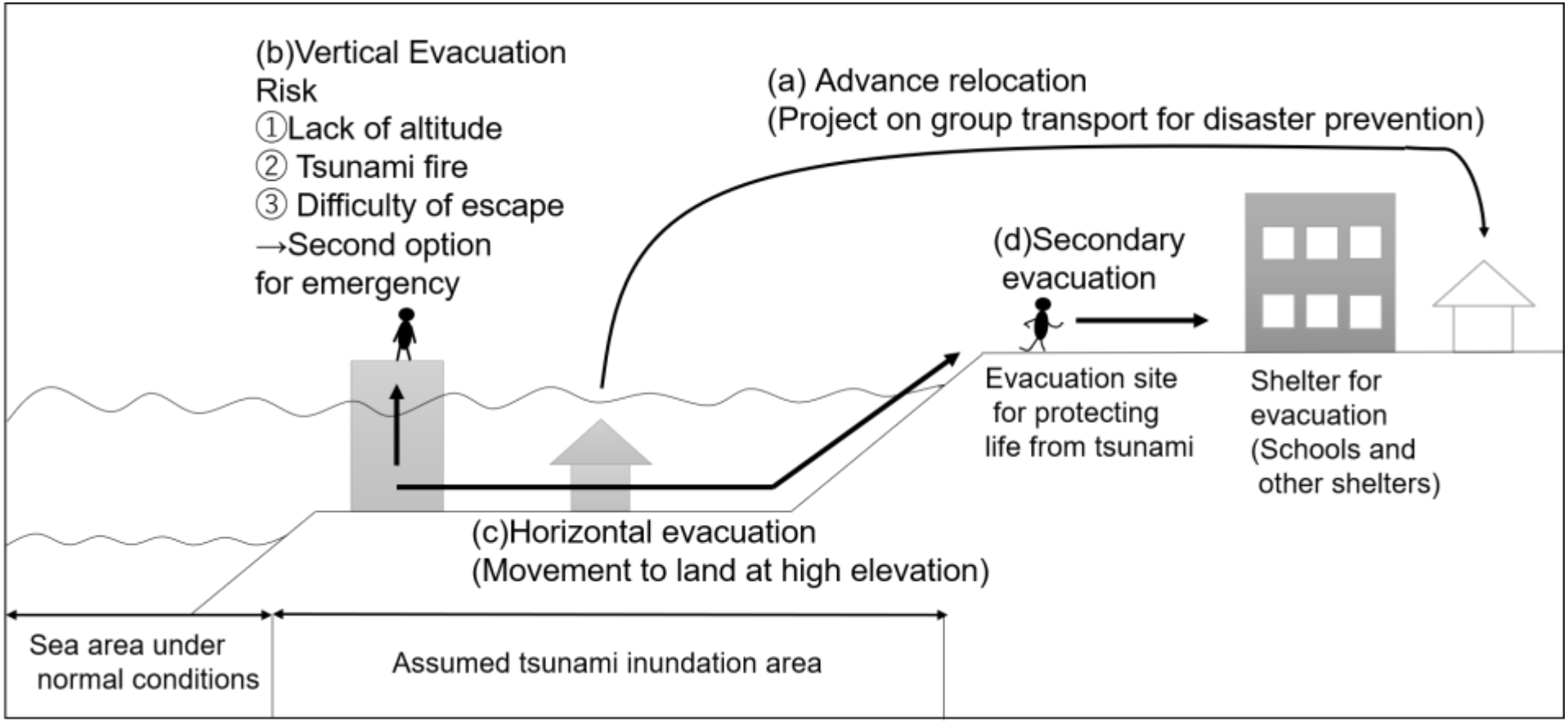


図　東海・東南海・南海３連動地震における津波浸水想定区域・津波避難困難地域の分布状況
【中部地域　串本中学校区（高富・二色・串本）】

How to save our lives from tsunami?



Space design of evacuation
for pedestrians (0.5-1.0m/sec)

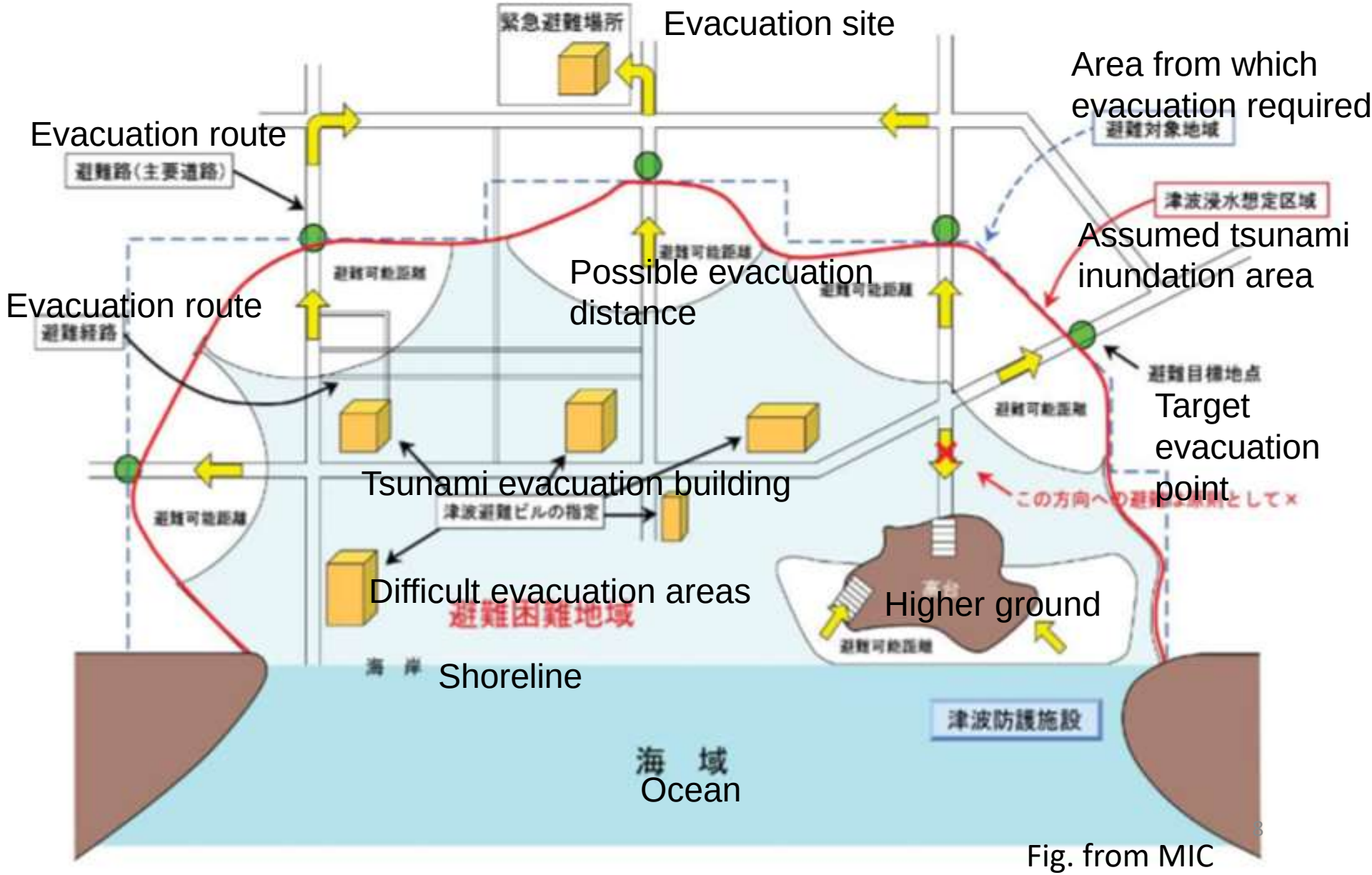


Fig. from MIC

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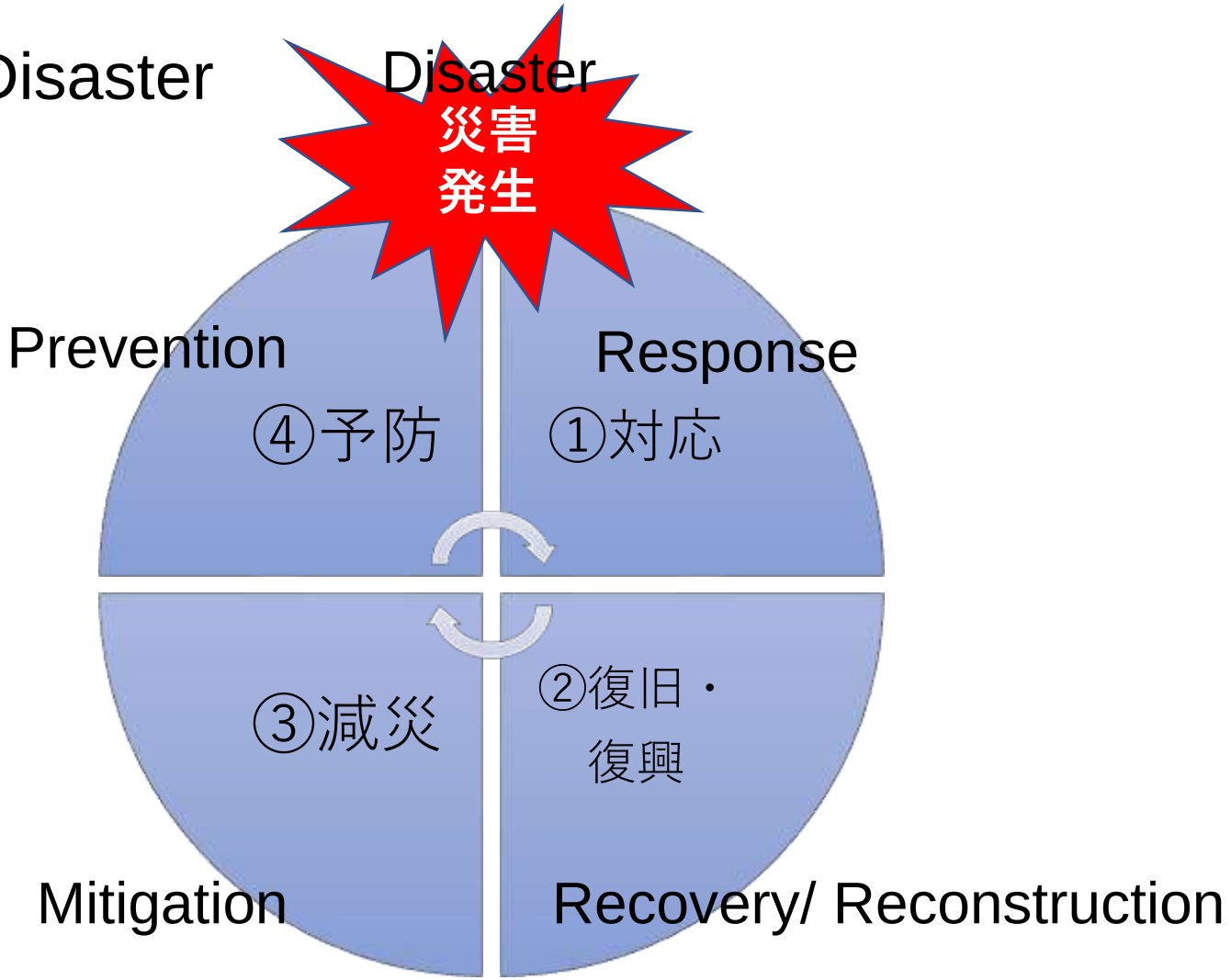
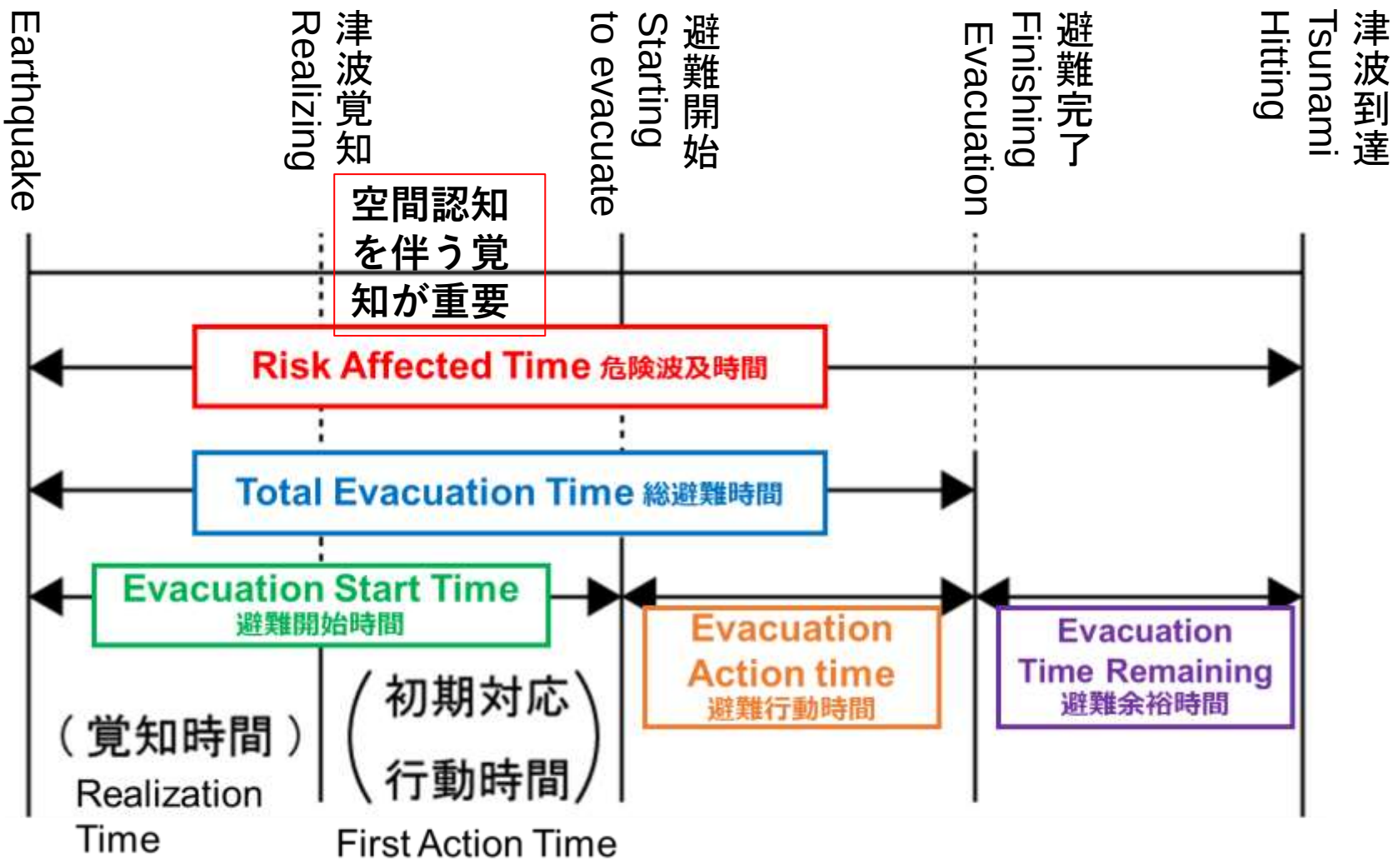
Cycle of Disaster



Evacuation action and Risk Affected Time (Tsunami)

避難行動と危険波及時間との時間的関係(津波)



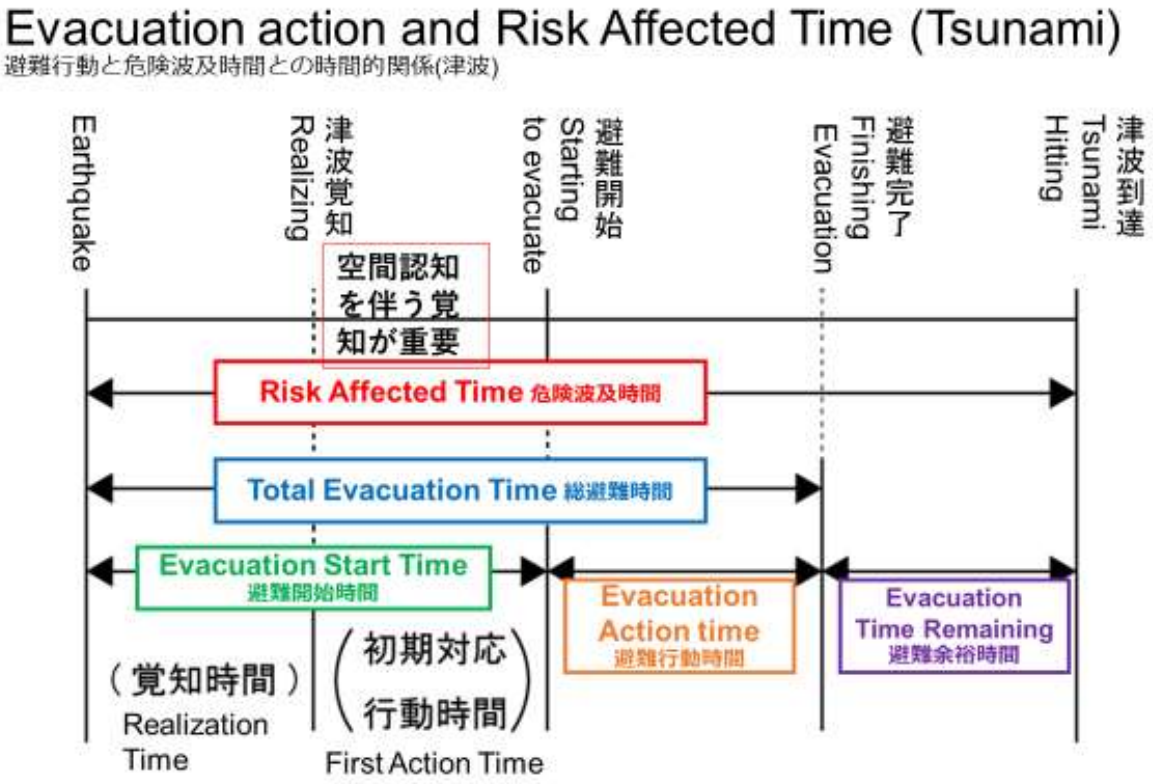
＊津波により危険が波及すると覚知した時を示す。(警報の発令を視聴した時ではない。)

出典：室崎益輝，現代建築学 建築防災・安全，1993年および
大津暢人，北後明彦，「市街地の津波避難訓練における住民による災害時要援護者の搬送速度と輸送－神戸市真陽地区におけるシルバーカー、介助車、車いすおよびリヤカーを用いた搬送避難－」，日本建築学会計画系論文集，Vol.82　No.734，2017.4をもとに筆者作成

Safety evaluation

Total Evacuation Time < Risk Affected Time

The safety of evacuation is assessed by
Evacuation Time Remaining



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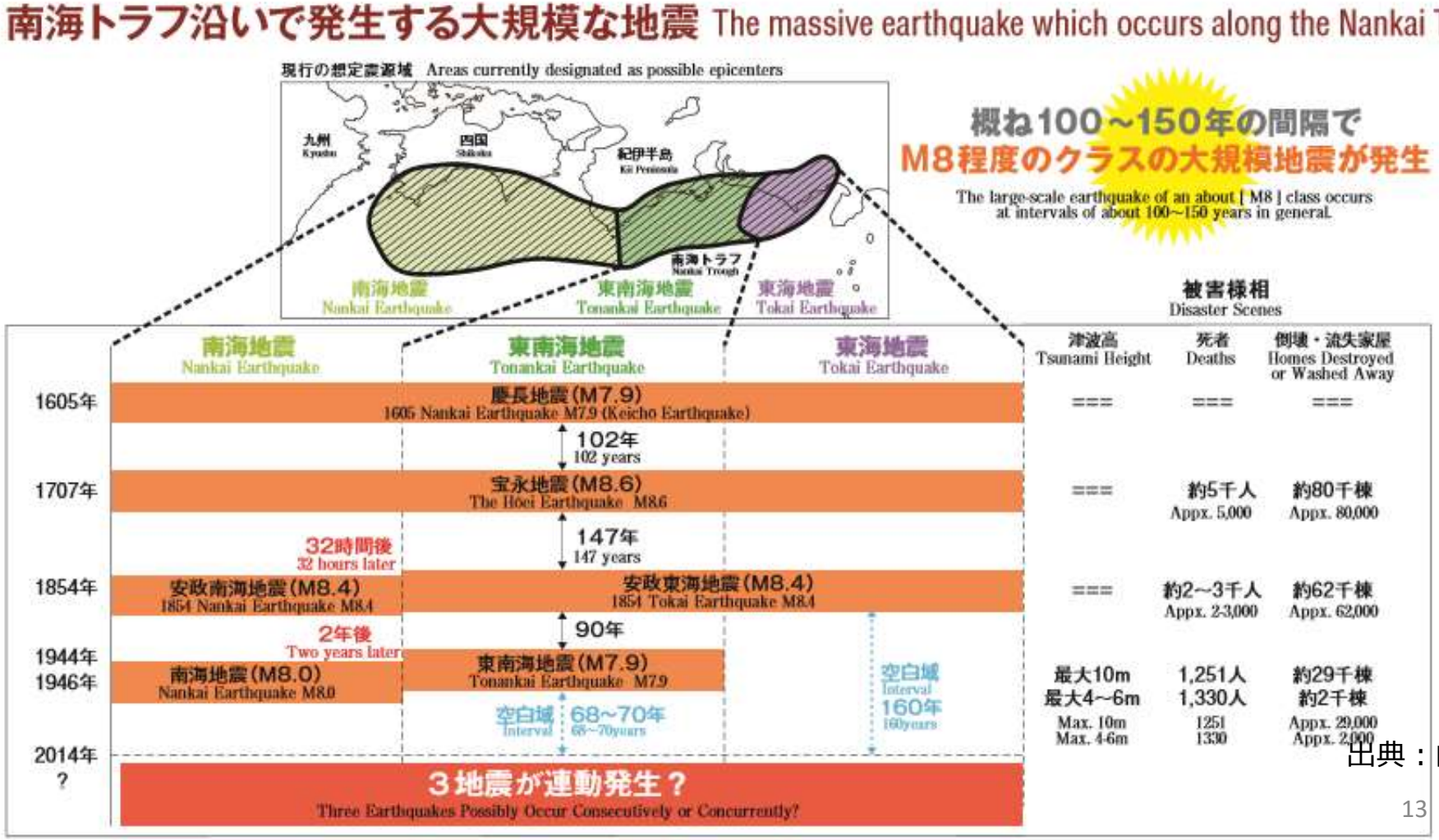
大津暢人，北後明彦，「市街地の津波避難訓練における住民による災害時要援護者の搬送速度と輸送－神戸市真陽地区におけるシルバーカー、介助車、車いすおよびリヤカーを用いた搬送避難－」，日本建築学会計画系論文集，Vol.82 No.734，2017.4をもとに筆者作成

History of Disaster

The oldest recorded Nankai trough earthquake is in 684 A.D.



出典：内閣府

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Background

2011 Great East Japan Earthquake

Deceased or missing people	
Vulnerable people	16.1%
+) Supporters	18.9%
Concerned to vulnerable people	**35.0%**

(Isozaki 2013)

Three types of equipment used in the experiment

A: Rollator B: Transport chair C: Wheelchair

Symbol	Equipments	Weight(kg)	Dimension(cm)						Principal use
			When stored			In use			
			Height	Width	Depth	Height	Width	Depth	
A	Rollator	5.7	76	50.5	46	81.5	50.5	60	Non- transport
B	Transport chair	9.3	85	55	31	90	55	62	Transport
C	Wheelchair	17.9	88	30	104	88	62	104	Transport

Assistant equipment for rollator

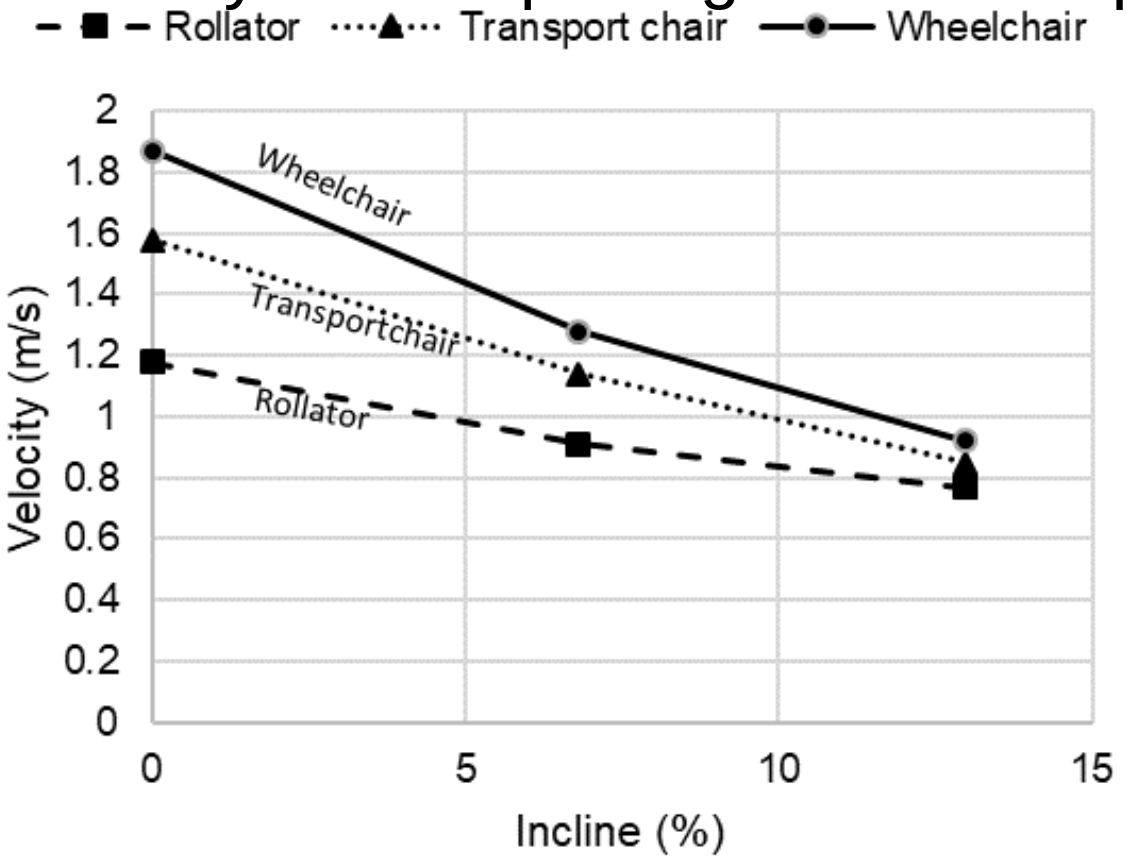
A person's feet reach the ground	A person's feet get caught in the ground	A person's feet are lifted by installing the assistant equipment
		
A rest position in a normal rollator	A moving position in a normal rollator	Installing the assistant equipment in a rollator
補助具なし	補助具装着時	足が持ち上げられる

Patent 特許第5802342号

シルバーカー用補助具
シルバーカーには車椅子や介助車に装備されているフットレストがないため、要援護者の足が接地した状態で搬送しようとすると、足が路面と機材下部の間に巻き込まれ前進できない。そこで、本実験では新たに開発した「シルバーカー用補助具」注1）を装着することにより要援護者の足を浮かせた状態に保持し、シルバーカーに緊急避難的に介助走行の用途を付加した。

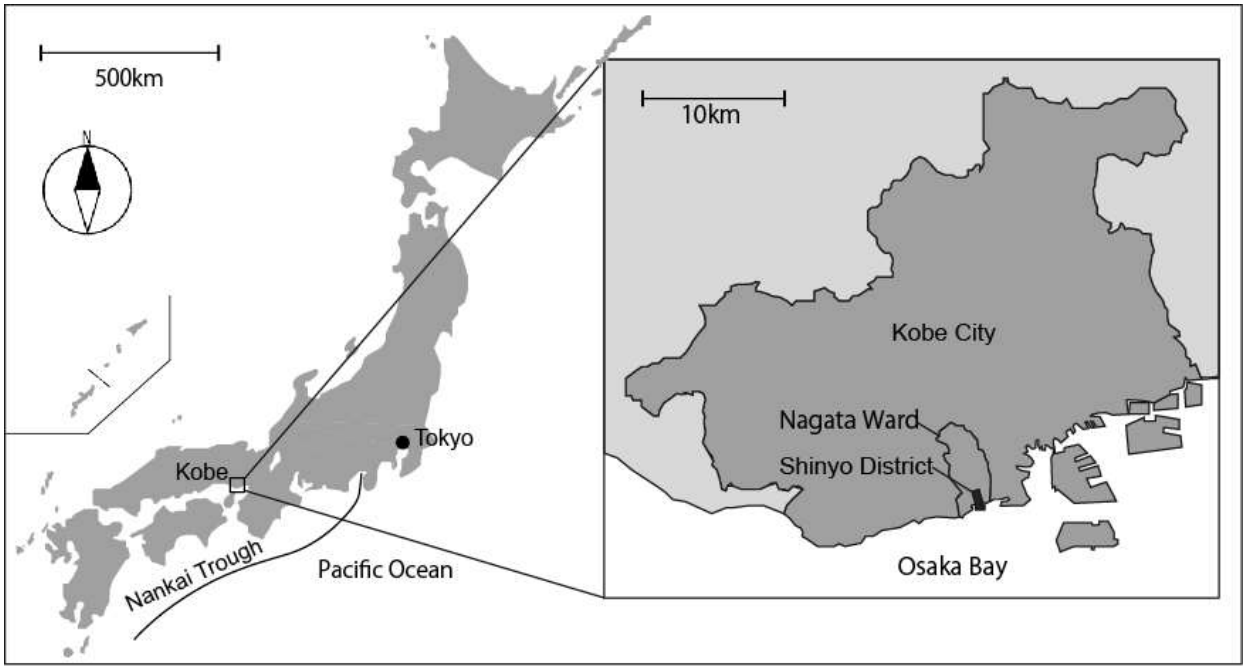

災害時要援護者の市
難実験（神戸大学
究センター安全都市
究室）
Steep
Gentle
Flat
平均勾配
12.99%
6.77%
0.00%
Rollators
Transport Chairs
Wheelchairs
平均速度 0.77 m/s
平均速度 0.91 m/s
平均速度 1.18 m/s
平均速度 0.85 m/s
平均速度 1.14 m/s
平均速度 1.58 m/s
平均速度 0.92 m/s
平均速度 1.28 m/s
平均速度 1.87 m/s

Average velocity of transporting vulnerable people



	Flat (0%)	Gentle slope (6.77%)	Steep slope (12.99%)
Wheelchair	1.87m/s	1.28m/s	0.92m/s
Transport chair	1.58m/s	1.14m/s	0.85m/s
Rollator	1.18m/s	0.91m/s	0.77m/s

Area Outline



Population, household and aging rate

	Shinyo District	Whole country
Population	5,896 (a)	
Number of households	3,036 (b)	
Average number of persons in a household (people)	1.94 (a/b)	2.51
Aging rate (%)	30.7	23.0 (FY2010)

"Comprehensive Survey of Living Conditions (FY2013)" by the Ministry of Health, Labour, and Welfare
Number of households and age (5-year step) per municipality in Kobe City (Census)
Results of the FY 2010 census (as of October 1, 2010)

BOKOMI=
Community Disaster Prevention Organization

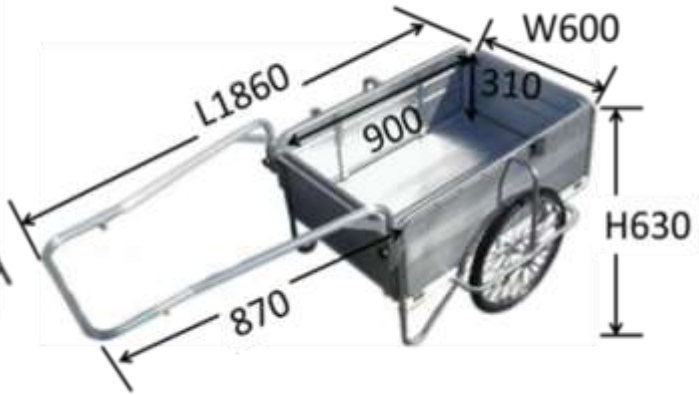
Led by citizen,
supported by municipality.

Equipment to carry vulnerable people

Rollator

Transport chair

Wheelchair



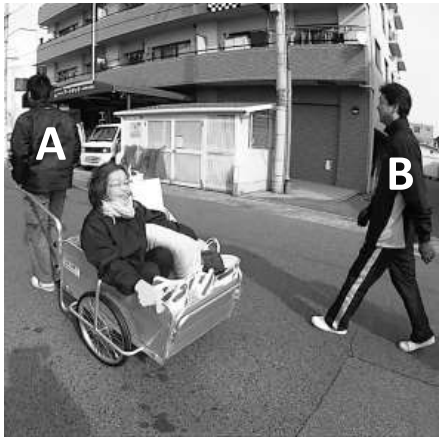
Cart

Drill date and assumptions

Date	17 January 2015	17 January 2016
Supposition	Great Nankai Trough Earthquake has occurred.	
Magnitude	9	
Seismic intensity	6 (Nagata ward, Kobe city)	
Warning	Great Tsunami Warning (along Setonaikai sea in Hyogo prefecture)	

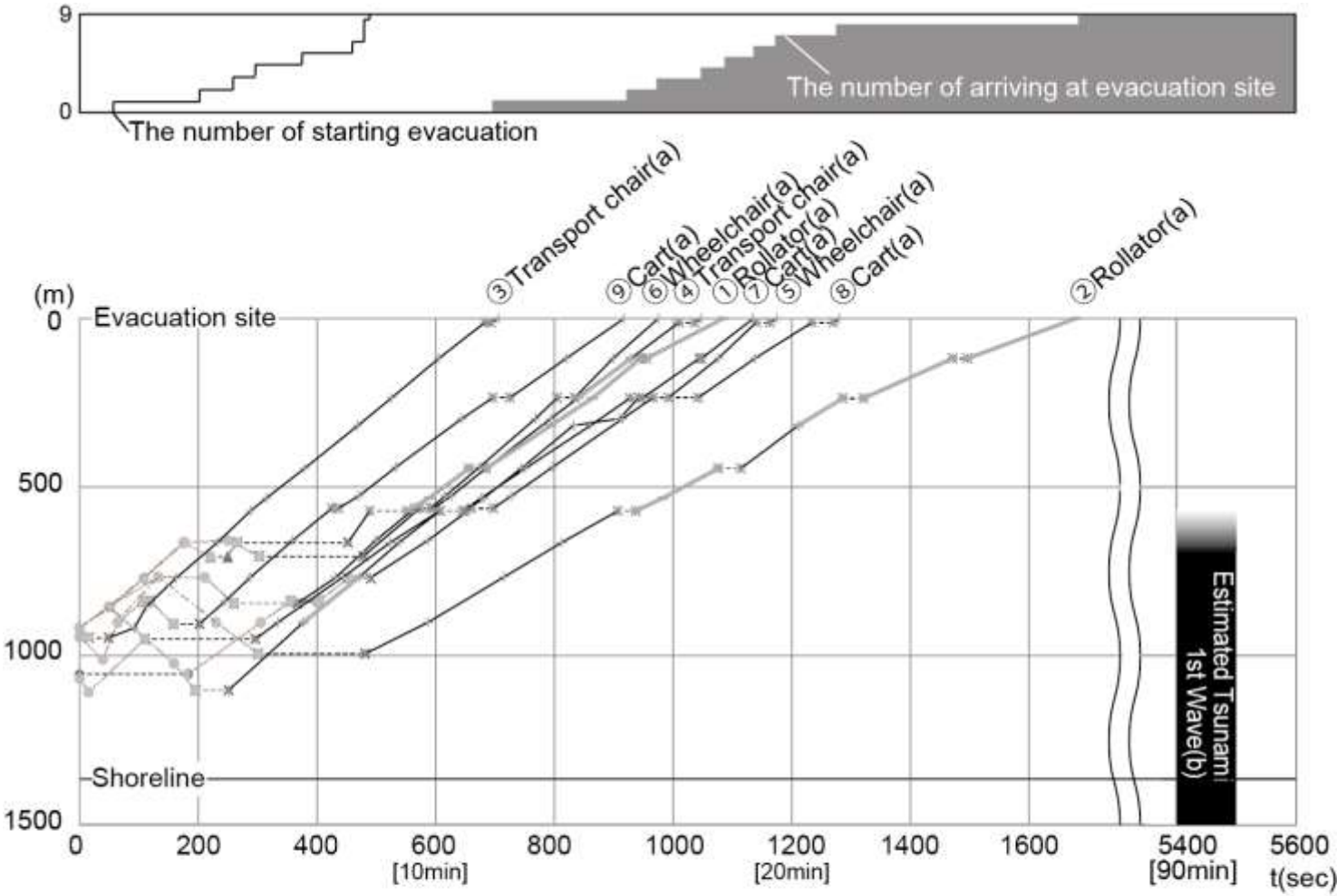
Drill
in 2015

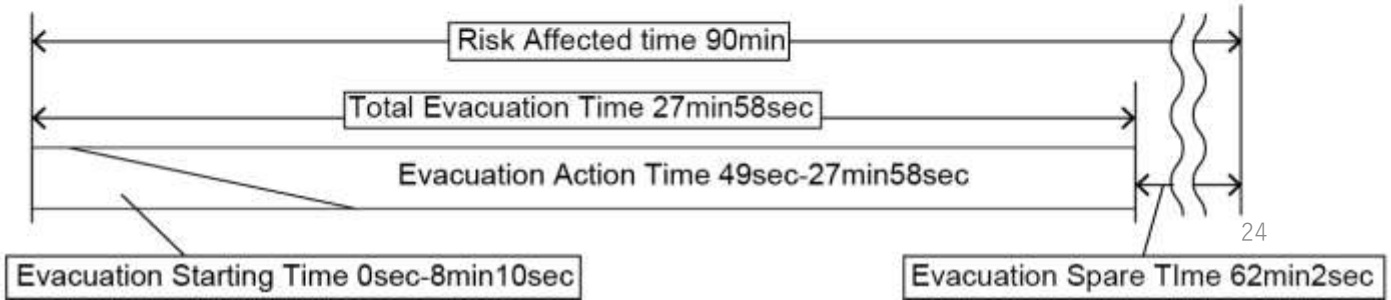
in 2016



Result (1) Evacuation diagram carrying vulnerable people

Every vulnerable person in this drill could evacuate within the project 90 minutes or tsunami hitting time.

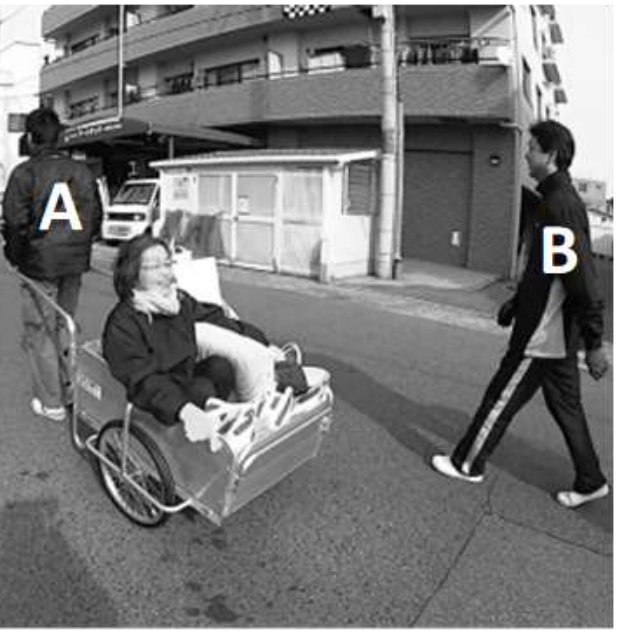




Result (2)

	Average speed	**Transportation ability**	**Transportation quantity**
Rollator	1.03m/s	3.7person・km/h	3.7person・km/h
Transport chair	1.42m/s	5.1person・km/h	5.1person・km/h
Wheelchair	1.50m/s	5.4person・km/h	5.4person・km/h
Cart	1.27m/s	4.6person・km/h	2.3person・km/h

Number of supporters for one vulnerable person
rollator/wheelchair/transport chair: 1 supporter
cart: 1 supporter/1.5 supporters/2 supporters
（based on 3 pulling methods）



Result (2)

Transportation ability

$$T_{ai} = \frac{Nv_{\max}}{Ns} \times V_i$$

Transportation quantity

$$T_{qi} = \frac{Nv_{onboard}}{Ns} \times V_i$$

T_{ai} Evacuation transportation ability
T_{qi} Evacuation transportation quantity
Ns Number of evacuation supporter(s)
Nv_{max} Maximum number of vulnerable person(s)
$Nv_{onboard}$ Number of vulnerable person(s) on board during evacuation
V*i* Velocity of instrument

	Transportation ability	**Transportation quantity**
Rollator	3.7person・km/h	3.7person・km/h
Transport chair	5.1person・km/h	5.1person・km/h
Wheelchair	5.4person・km/h	5.4person・km/h
Cart	4.6person・km/h	2.3person・km/h

plan

drill in 2015

Evaluation meeting in 2015

Purchase and installation of carts

drill in 2016

Evaluation meeting

Discussion

1, Natural human response
(Psychological effects)

2, Uncertainties of supporters

3, Means of transportation

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Estimated transport evacuation time

$$Ts = \sum_{i=1}^{n} \left\{ \frac{Di}{(-0.0278Ii + 1.0133)} \right\} + \frac{H}{0.18}$$

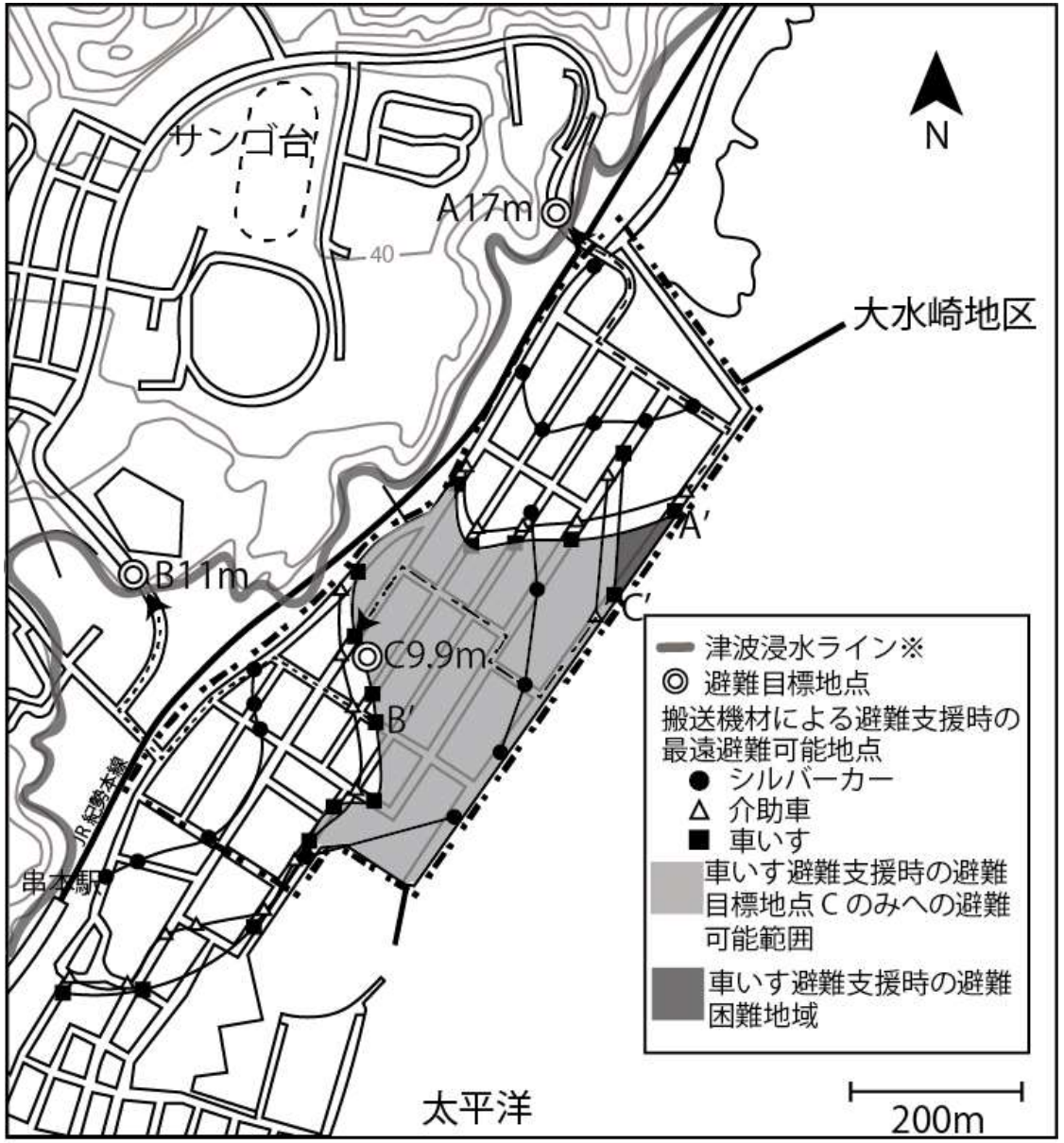
$$Tt = \sum_{i=1}^{n} \left\{ \frac{Di}{(-0.0501Ii + 1.4068)} \right\} + \frac{H}{0.18}$$

$$Tw = \sum_{i=1}^{n} \left\{ \frac{Di}{(-0.0587Ii + 1.4732)} \right\} + \frac{H}{0.18}$$

T Estimated transport evacuation time
s Rollator
t Transport chair
w Wheelchair
D Section distance
Ii Incline of section I
H Height of stairs

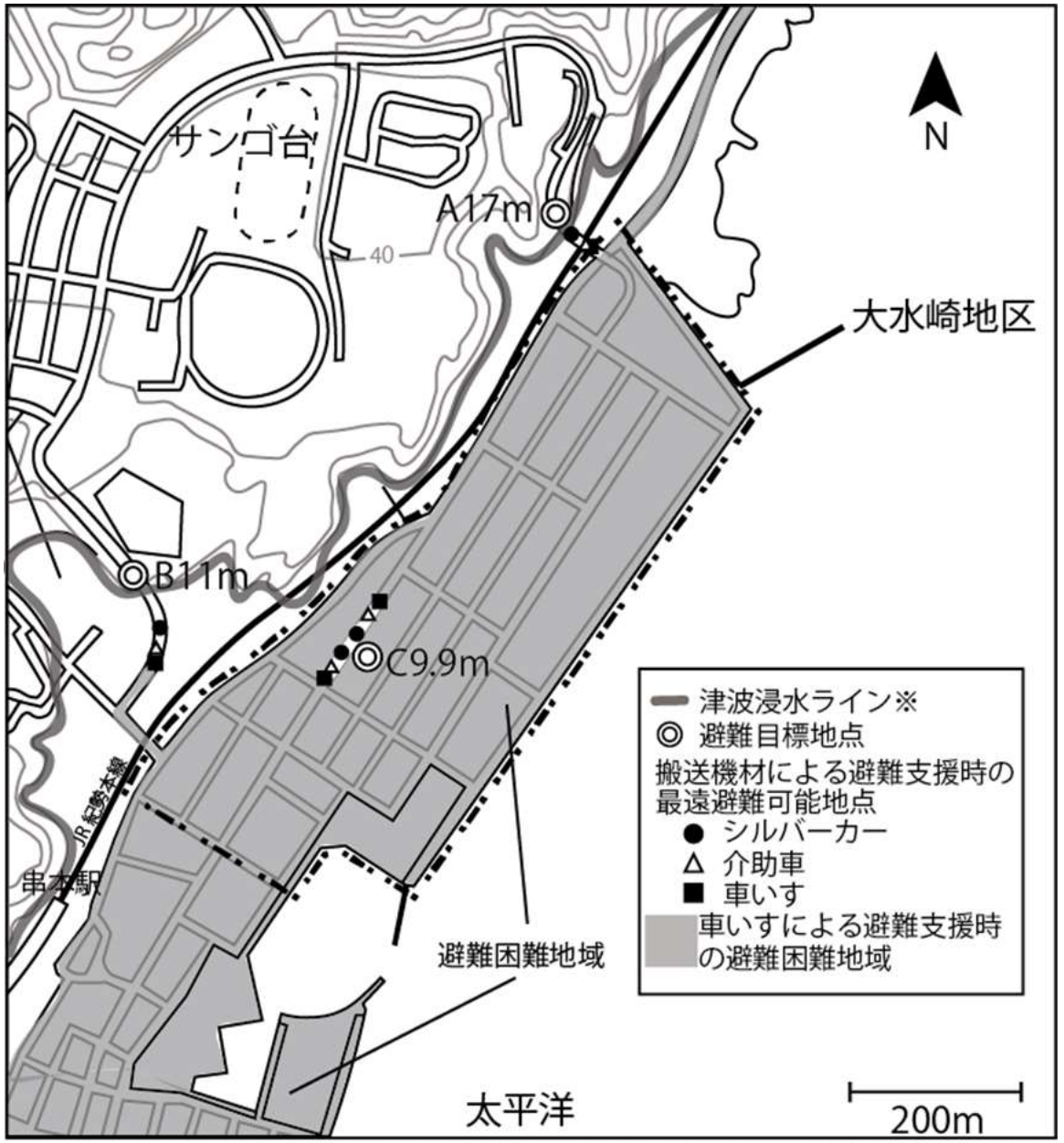
Case1
Evacuation start time 0 min.
Evacuation action time 6 min.

This figure shows estimated area where it is difficult for vulnerable people to evacuate when the tsunami comes.
The range of the area changes depending on evacuation start time and evacuation action time.

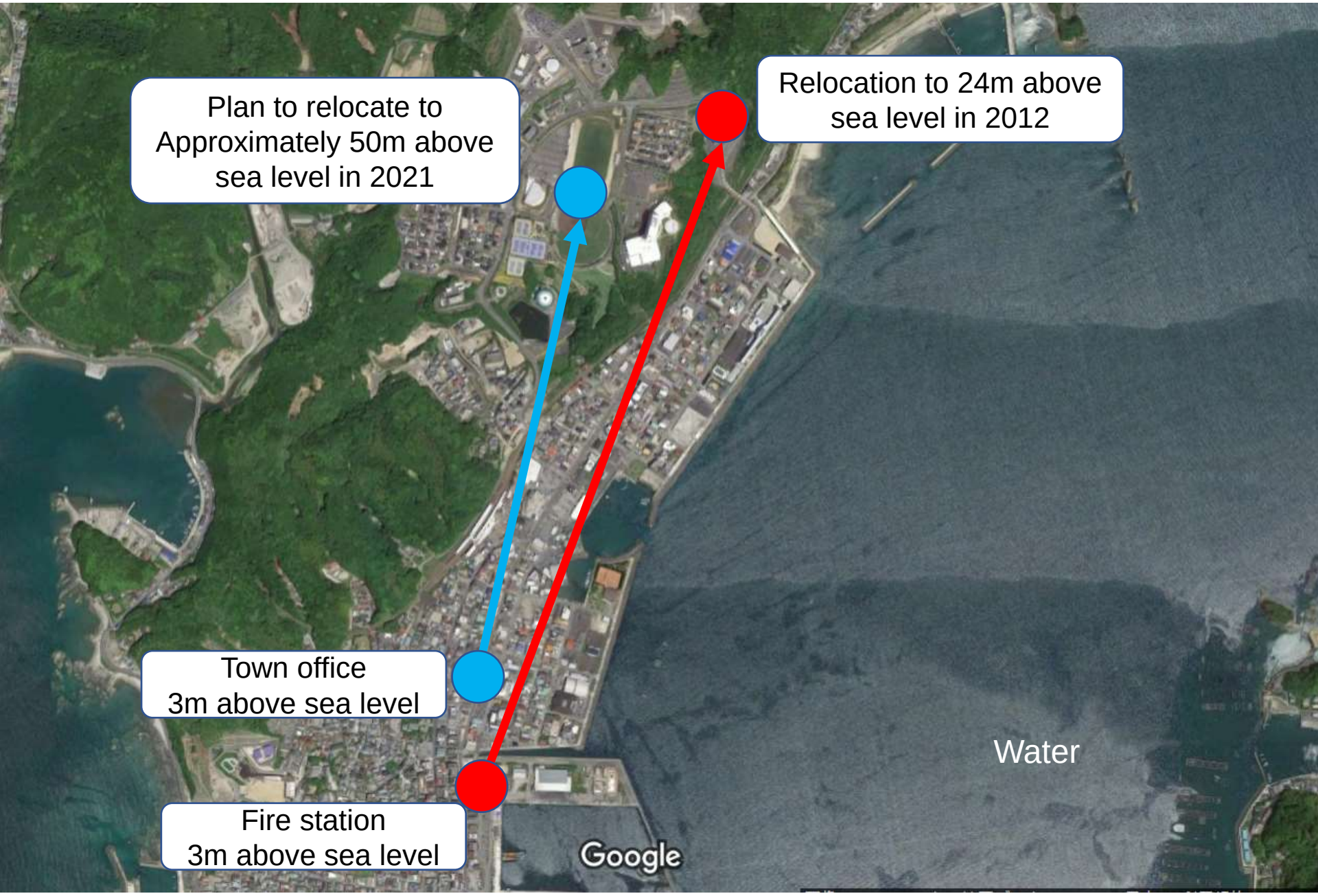


※津波浸水ラインは串本町役場総務課：串本町津波ハザードマップ（平成 26 年 3 月作成）を参照
http://www.town.kushimoto.wakayama.jp/file/bousai/map/1920.pdf(2017.1.6 アクセス)

Case2
Evacuation start time 5 min.
Evacuation action time 1 min.



※津波浸水ラインは串本町役場総務課：串本町津波ハザードマップ（平成 26 年 3 月作成）を参照
http://www.town.kushimoto.wakayama.jp/file/bousai/map/1920.pdf(2017.1.6 アクセス)


Plan to relocate to Approximately 50m above sea level in 2021
Relocation to 24m above sea level in 2012
Town office 3m above sea level
Fire station 3m above sea level
Water
Google

References

-Nobuhito Ohtsu, Akihiko Hokugo

Velocity and transportation ability of vulnerable people during a community tsunami evacuation drill: Outdoor evacuation using a rollator, transport chair, wheelchair, and cart in Shinyo Bokomi, Kobe, Japan, JAPAN ARCHITECTURAL REVIEW Vol.2 Issue4 p576～587, 2019, DOI : https://doi.org/10.1002/2475-8876.12118

-Nobuhito Ohtsu, Akihiko Hokugo, Abel Táiti Konno Pinheiro, Jihyang Lee

Feasibility of evacuating vulnerable people during a tsunami: Comparing assistant velocities with a wheelchair, transport chair, and rollator on three different inclines outdoors, JAPAN ARCHITECTURAL REVIEW Vol.3 Issue2 p218～230, 2020, DOI：https://doi.org/10.1002/2475-8876.12140、

Jan. 26, 2021

Asian Disaster Reduction Center Online Tsunami Seminar
Community Space Design
for Tsunami Disaster Risk Reduction

Thank you very much for your attention!!

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