![WEFTEC 2019 — the water quality event]

FLOOD RISK ASSESSMENT BASED ON REGIONAL CHARACTERISTICS IN CASE OF INTENSE RAINFALL EXCEEDING DESIGN STANDARDS

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Flow of Today's Presentation

1. Introduction
2. Rainfall Solutions up to Now
3. Evaluation of Flooding Risks
4. Results of Initiatives
5. Conclusion

Outline of Yokohama
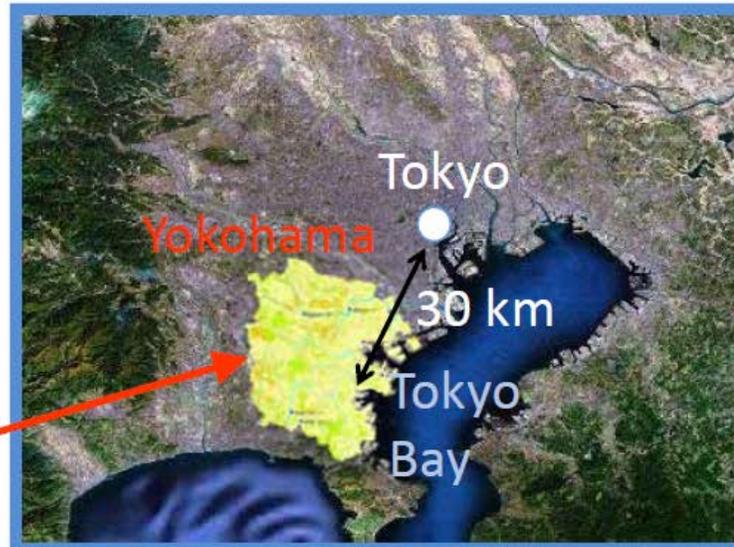
City Information	
Area	435 km^2
Population	3.7milion
Sewer Coverage	99.9%

Introduction

Rainfall Characteristics in Japan

Worldwide annual mean precipitation: 880 mm

⬇ Approximately double

Japanese annual mean precipitation: 1,718 mm

Comparison of Annual Average Precipitation

	Japan	World
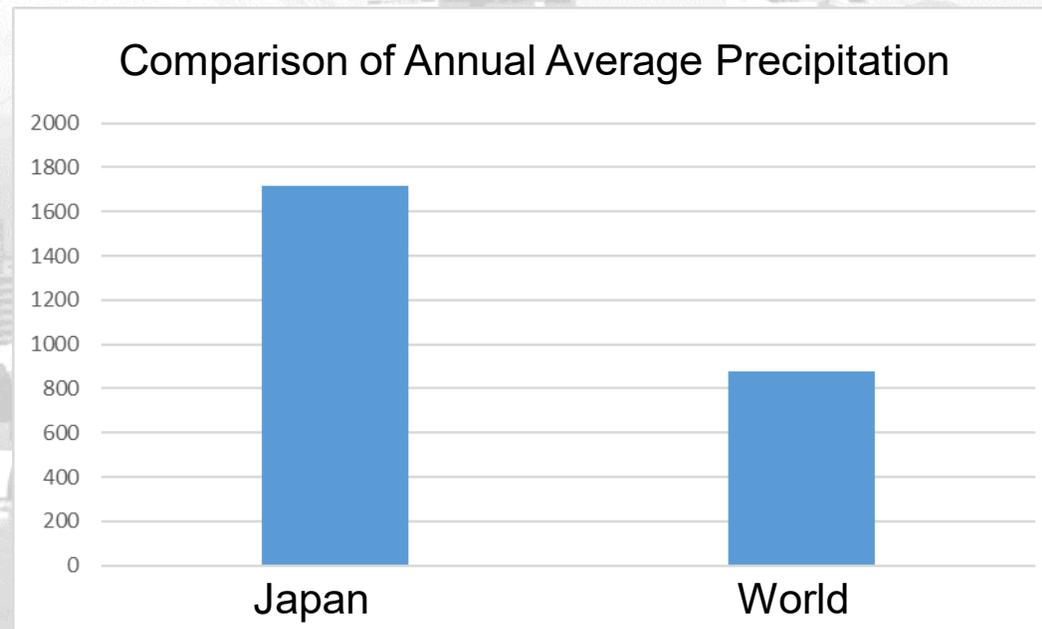
Introduction

Increase in Localized Torrential Rain in Japan

Meteorological Agency Statistics

Average occurrence frequency of rainfall of 50mm or more in 1 hour in the ten-year period between 1976-1985 compared to 2008-2017 shows an increase of approximately 1.4 times the frequency
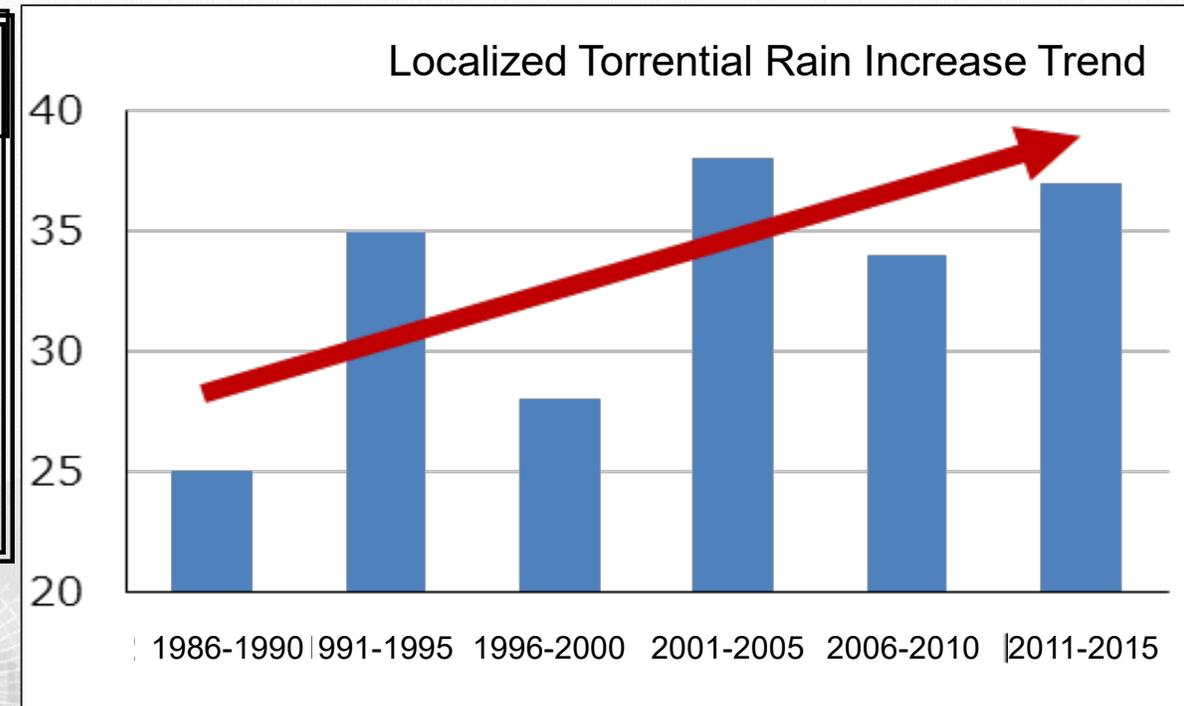
Reason for increase

⇩

Rise in temperature due to climate change

Localized Torrential Rain Increase Trend

| | 1986-1990 | 1991-1995 | 1996-2000 | 2001-2005 | 2006-2010 | 2011-2015 |

Occurrence frequency of localized torrential rain (50 mm/h or more)

Introduction

Rainfall Images

What the rain looks like	Moderately heavy rain	Heavy rain	Torrential rain	Extreme torrential rain
	10-20 mm/h	20-30 mm/h	30-50 mm/h	50-80 mm/h
	Heavy	Drenching	Bucketing down	Like being in a waterfall
	Legs get wet from water splashing up	You get wet even if you use an umbrella	You get wet even if you use an umbrella	An umbrella is of no use

Rainfall Solutions up to Now

Areas without Pumps, 50 mm/h once every five years

Areas with Pumps, 60 mm/h once every ten years
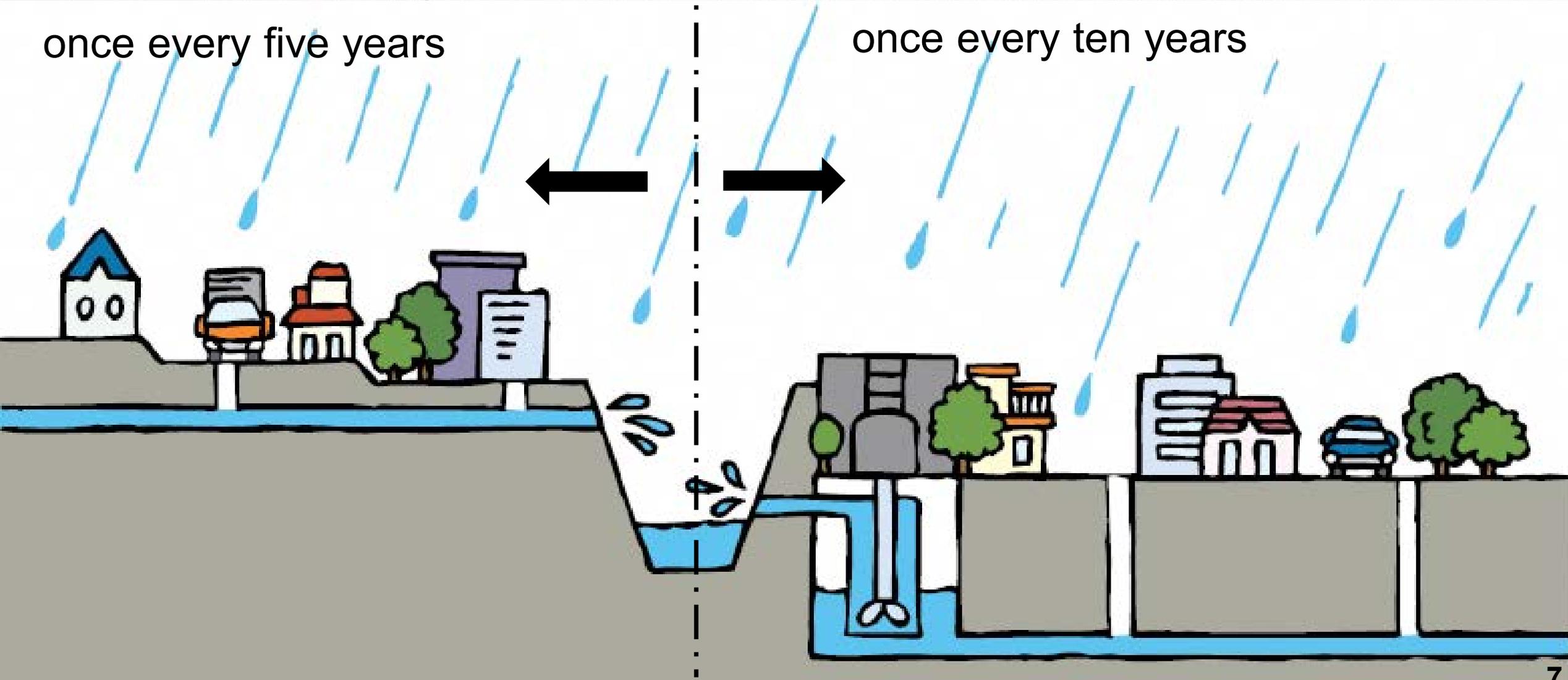
Rainfall Solutions up to Now

<structural solutions>

stormwater drainage facilities
such as storm sewers

stormwater storage facilities as
storm reservoirs

< non-structural
solutions >

Green
infrastrucure
Flood map

etc

Targeted intensity

structural solutions

Large-scale rainwater storage pipe
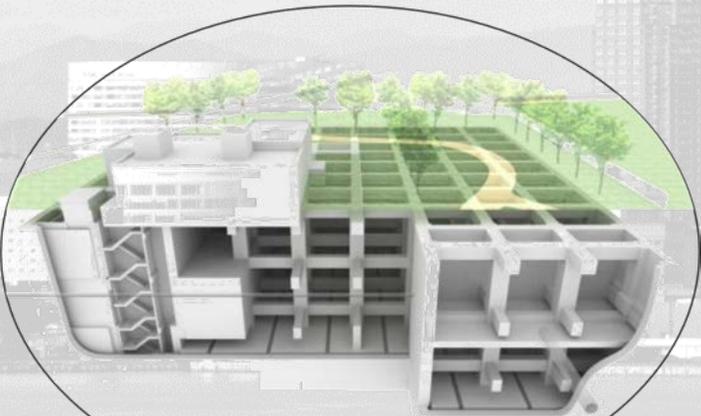
Flood control reservoir

Very expensive

Great deal of time required from design phase to usage phase.

Evaluation of Flooding Risks

Flood Control from Innovative Perspectives

perspectives of "advance disaster prevention and disaster reduction" and "selection and concentration" approaches.
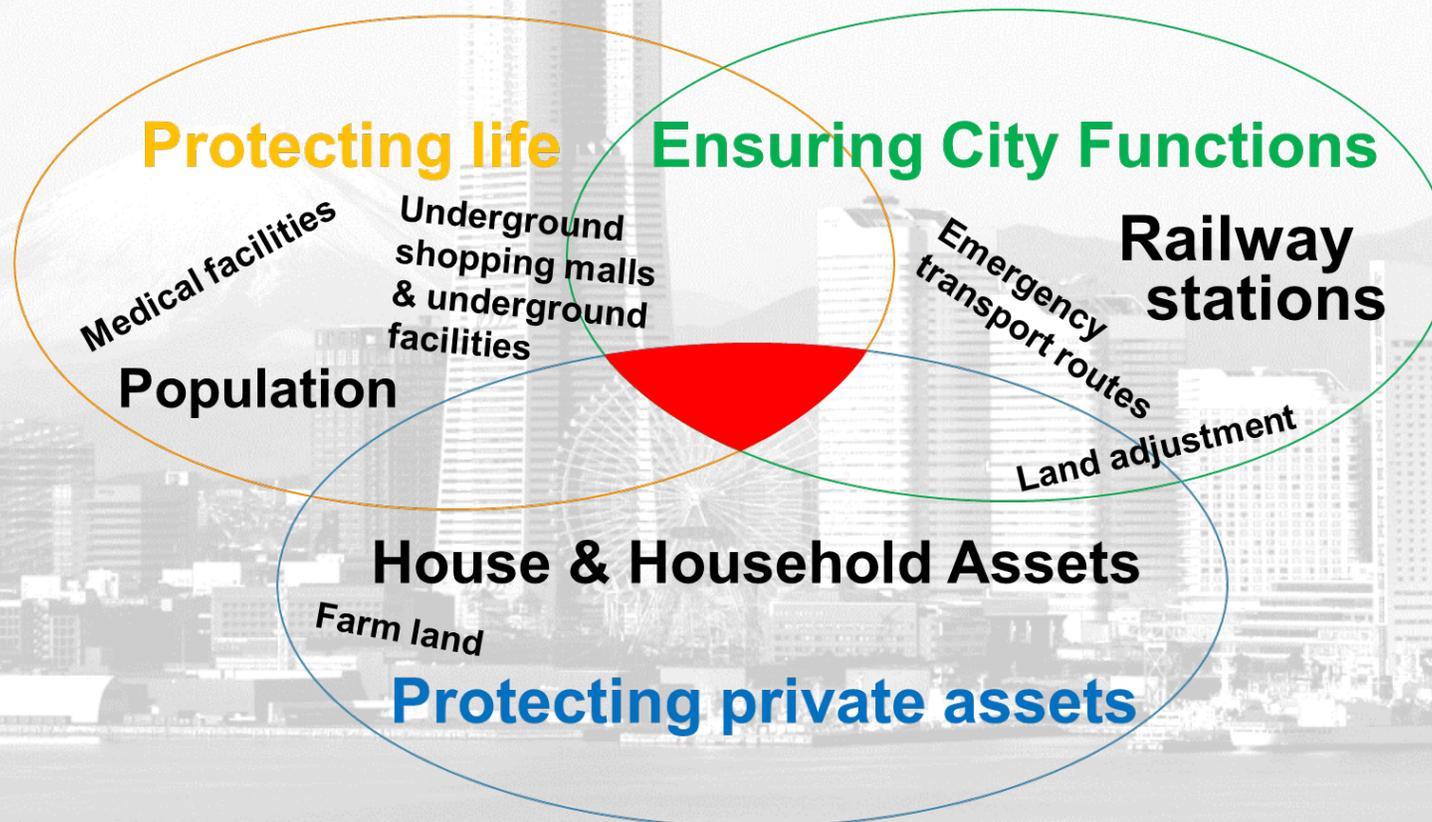
Evaluation of Flooding Risks

Establishing the Rainwater Management

Masterplan

"Yokohama Rainwater Management Implementation Plan 2018" established
to organize flood control from the innovative viewpoints of establishing effective flood control, "advance disaster prevention and disaster reduction" as well as "selective and concentration" approaches.

横浜市雨水管理実行計画 2018

平成 31 年 3 月
横浜市環境創造局

Evaluation of Flooding Risks

 # Setting Target Rainfall

Maximum rainfall in history	This is a rainfall greater than the wastewater plan caters for. Recently, the rainfall in 2003 (76.5 mm/h) caused the most damage ever.

Setting Target Flood Level
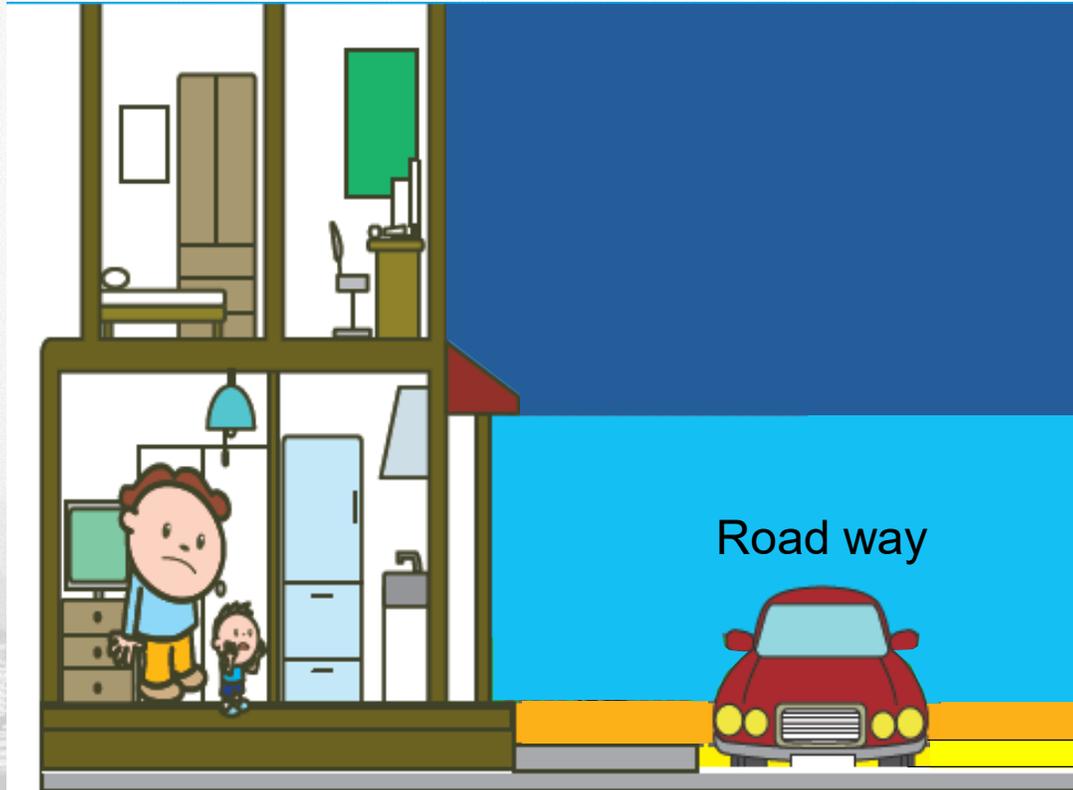
G.L + approximately 8 inches

Road way

G.L $\pm$ 0

Evaluation of Flooding Risks

Use analysis models and GIS to evaluate by scoring in order to evaluate risk of flooding and set preparation priority

Set and define excessive rainfall

↓

evaluate of current infrastructure

↓

Select target area

Consider evaluation indexes

↓

prioritizing sewersheds for investment

↓

summarizing results
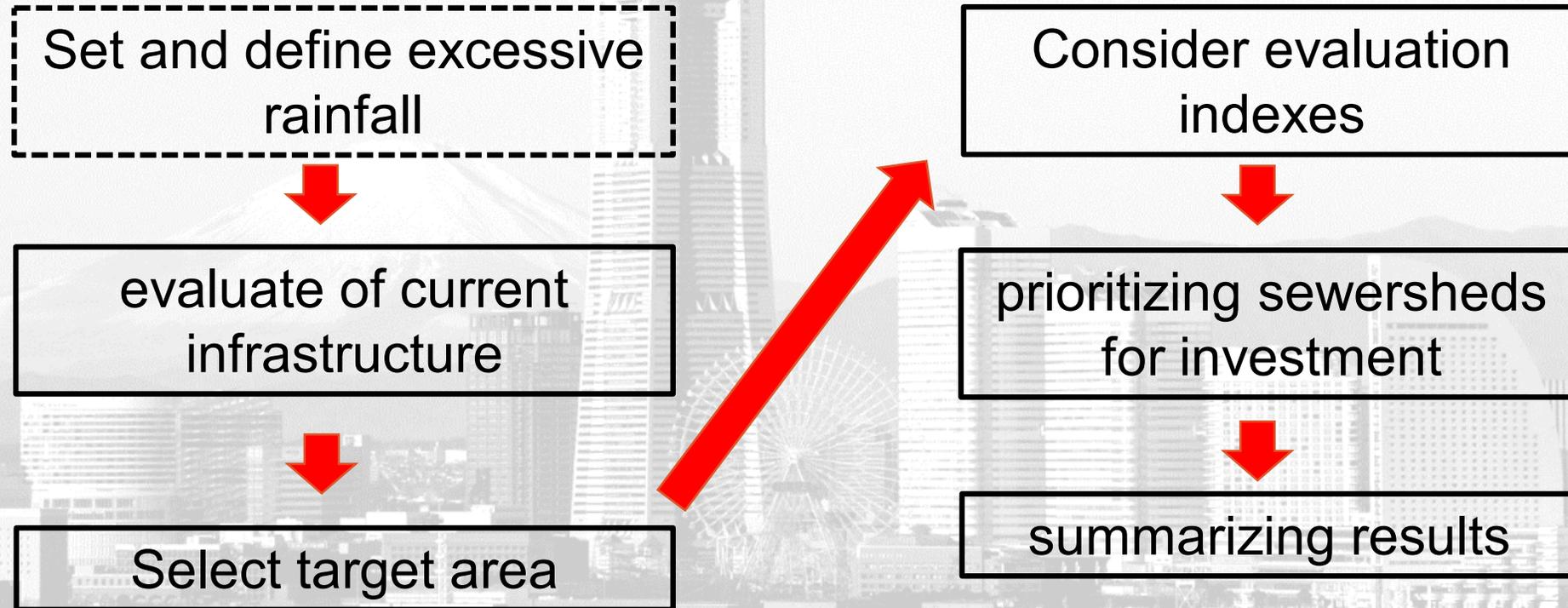
Evaluation of Flooding Risks

evaluate of current infrastructure

Making use of "runoff analysis model" used to create land-side flooding hazard map, the capacity of rainwater drainage facilities evaluated.

Existing rainwater drainage facilities

\# Wastewater sewers (rainwater pipes, junction pipes)
\# Irrigation channel
\# Roadside ditch (U-shaped ditch)
\# Storage facilities (flood-control reservoirs)

Evaluation of Flooding Risks

An Example of Evaluation Results
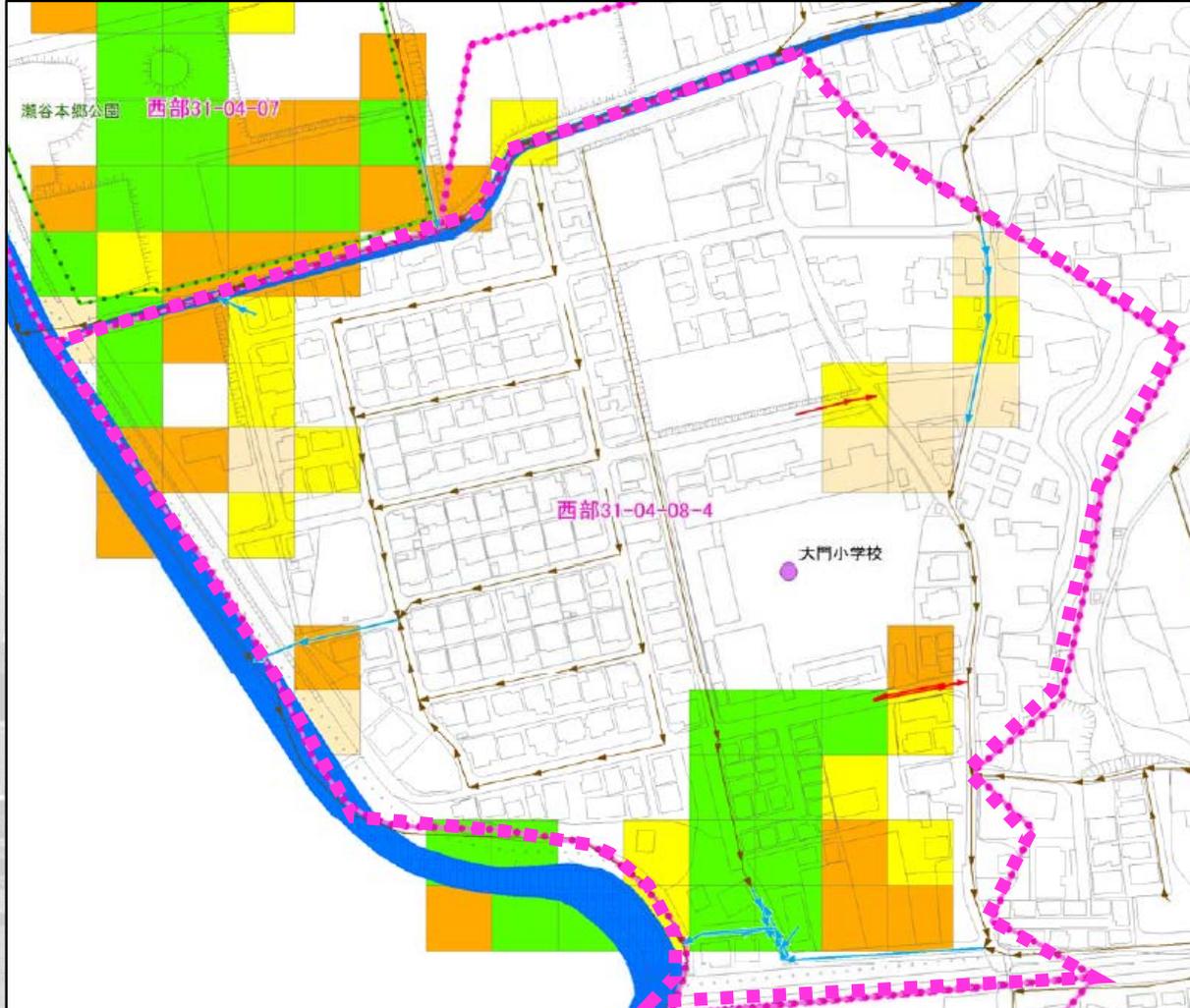
🟩 :	Areas that are assumed will flood
	* Flood depth color coded
⬚ :	Target area (trunk sewer catchment basin
← :	Rainwater drainage facilities
🟦 :	River (waterway in some parts)

Evaluation of Flooding Risks

Selecting Target Areas

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600 areas /
6,000 areas

（Image）

Legend
Flooding history & risk level

	Flooding history
	Flooding risk level
	Flooding history & risk level
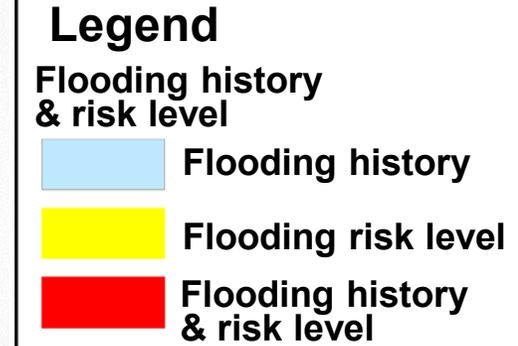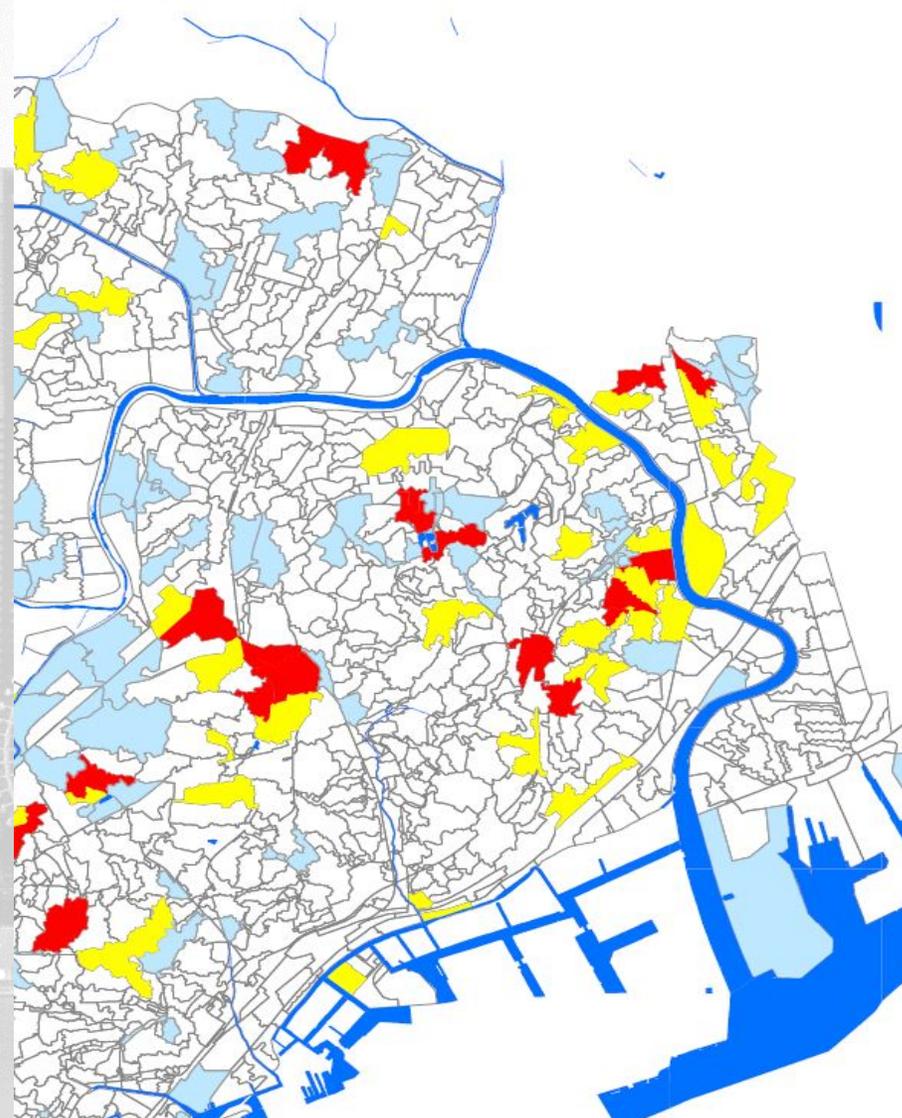
Evaluation of Flooding Risks

Considering Evaluation indexes

The important perspective is what needs to be viewed seriously in flood control measures – namely, what needs to be protected from damage?

Hazards × **Exposure** × **Vulnerability**

Hazards
Scales of rainfall and damage

Exposure
Topography ,elevation
Rainwater discharge capacity
Storage & permeation capacities, etc.
Population, asset sum
Facilities requiring consideration, disaster prevention facilities

Vulnerability
Configuration of land use
Underground shopping malls, underground facilities
Terminal stations, railway stations
Trunk roads, emergency transportation routes
Areas with accumulated city functions

Evaluation of Flooding Risks

Considering Evaluation indexes

（Examples）
　# Areas with accumulated city functions (underground shopping mall, terminal station)
　# Areas with high concentration of important facilities (disaster prevention facilities and care facilities)
　# Areas with high concentration of population and assets (residential areas and farm land)

Level of importance is set for each index because the degree of flood damage varies.

（Image）

Station

Rice field

History of flooding
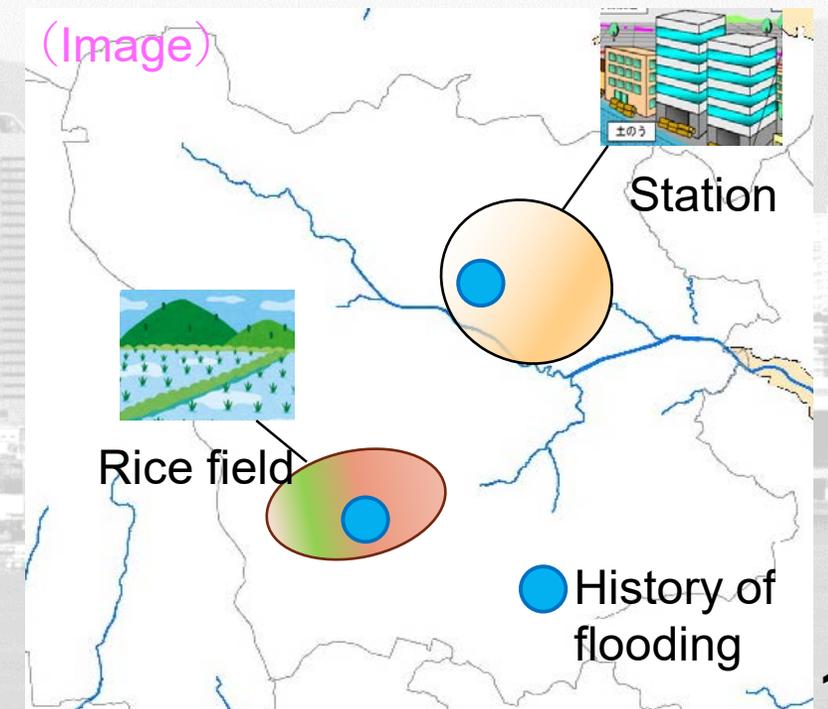
Evaluation of Flooding Risks

Index Weighting

	Analytic Hierachy Process (AHP)
Outline	For evaluation indexes related to level of importance of each index, a weighting coefficient unique to the local public body is set by conducting a pairwise comparison survey of all items involved.
Merits	- Subjectivevalue criteria (criteria instinctively held by each person) used to select alternative solutions with best evaluation. -There are multiple evaluation criteria, which resolve the problem of a mutual lack of common measurements.
Demerits	- It is important to create a hierachic structure, and results influence that, which introduces a fear of designer bias. - The number of indexes set will determine how vast the work of the pairwise comparison becomes, which may become the burden of the decision makers.

Survey conducted using AHP.
 * Respondents drawn from managerial positions and higher of Sewerage Works
   Management Division (60 people/960 people)

Evaluation of Flooding Risks(Actual Examples of AHP)

	Item on left has high importance																	Item on left has high importance
	←															→		
The proportional level of high importance of item on right compared to item on left	9	8	7	6	5	4	3	2	1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	
Flooding history	○																	Projected flooding
Flooding history								○										Population
Flooding history							○											Underground shopping malls & underground facilities

⋮

Evaluation of Flooding Risks(Actual Examples of AHP)

Pairwise comparison	Item on right															
Item on left	Flooding history	Projected flooding	Population	Underground shopping mall & Underground facilities	Care facilities	Disaster prevention facilities	Area with accumulated city functions	Terminal station	Railway station	Trunk roads & emergency transportation routes	House & Household assets	Workplace assets	Farm land	Workability	Preparation cost (C)	Preparation efficiency (B/C)
Flooding history	1	3	7	3	3	1/3	1/5	1/5	1/4	1/5	1/3	1/3	3	7	7	7
Projected flooding	1/3	1	3	1	1	1/5	1/7	1/7	1/6	1/7	1/5	1/5	1	5	5	5
Population	1/7	1/3	1	1	1	1/5	1/7	1/7	1/6	1/7	1/5	1/5	5	5	5	1
Underground shopping mall & Underground facilities	1/3	1	1	1	1	1	1	1	3	1	3	1	1/3	3	3	3
Care facilities	1/3	1	1	1	1	1	1	1	1	1/3	1	1	1	3	3	3
Disaster prevention facilities	3	5	5	1	1	1	1	1	1	1	3	2	1	3	3	3
Area with accumulated city functions	5	7	7	1	1	1	1	1	1	1	3	2	3	3	3	3
Terminal station	5	7	7	1	1	1	1	1	1	1	1/2	1	1/2	3	3	3
Railway station	4	6	6	1/3	1	1	1	1	1	1	1/2	1	2	3	3	3
Trunk roads & emergency transportation routes	5	7	7	1	3	1	1	1	1	1	4	3	1/2	4	4	4
House & Household assets	3	5	5	1/3	1	1/3	1/3	2	2	1/4	1	1/2	1/3	4	4	4
Workplace assets	3	5	5	1	1	1/2	1/2	1	1	1/3	2	1	3	4	4	4
Farm land	1/3	1	1/5	3	1	1	1/3	2	1/2	2	3	1/3	1	3	3	3
Workability	1/7	1/5	1/5	1/3	1/3	1/3	1/3	1/3	1/3	1/4	1/4	1/4	1/3	1	1	1
Preparation cost (C)	1/7	1/5	1/5	1/3	1/3	1/3	1/3	1/3	1/3	1/4	1/4	1/4	1/3	1	1	1/8
Preparation efficiency (B/C)	1/7	1/5	1	1/3	1/3	1/3	1/3	1/3	1/3	1/4	1/4	1/4	1/3	1	8	1

Evaluation of Flooding Risks(AHP Results)

Indexes	Weight setting
Flooding history	0.139
Projected flooding	0.090
Disaster prevention facilities	0.088
Underground shopping mall & underground facilities	0.080
Terminal station	0.076
Trunk roads & emergency transportation routes	0.073
Area with accumulated city functions	0.072
Preparation efficiency (B/C)	0.061
Care facilities	0.060
Preparation cost (C)	0.049
Population	0.048
Railway station	0.048
Workability	0.035
House & household assets	0.034
Workplace assets	0.031
Farm land	0.016
Total	1.000

Prioritizing sewersheds for investment

Each index is tabulated and allotted a score using normal distribution, as there are differences in the quantities of facilities held by areas.

"Flooding History"

Alloted scores	Maximum value of index	Number of areas
5	0.9684	26
4	0.0861	112
3	0.0046	185
2	0.0009	113
1	0.0001	26
0	0.0000	198
Total		660

(Unit: Houses/ha)

24
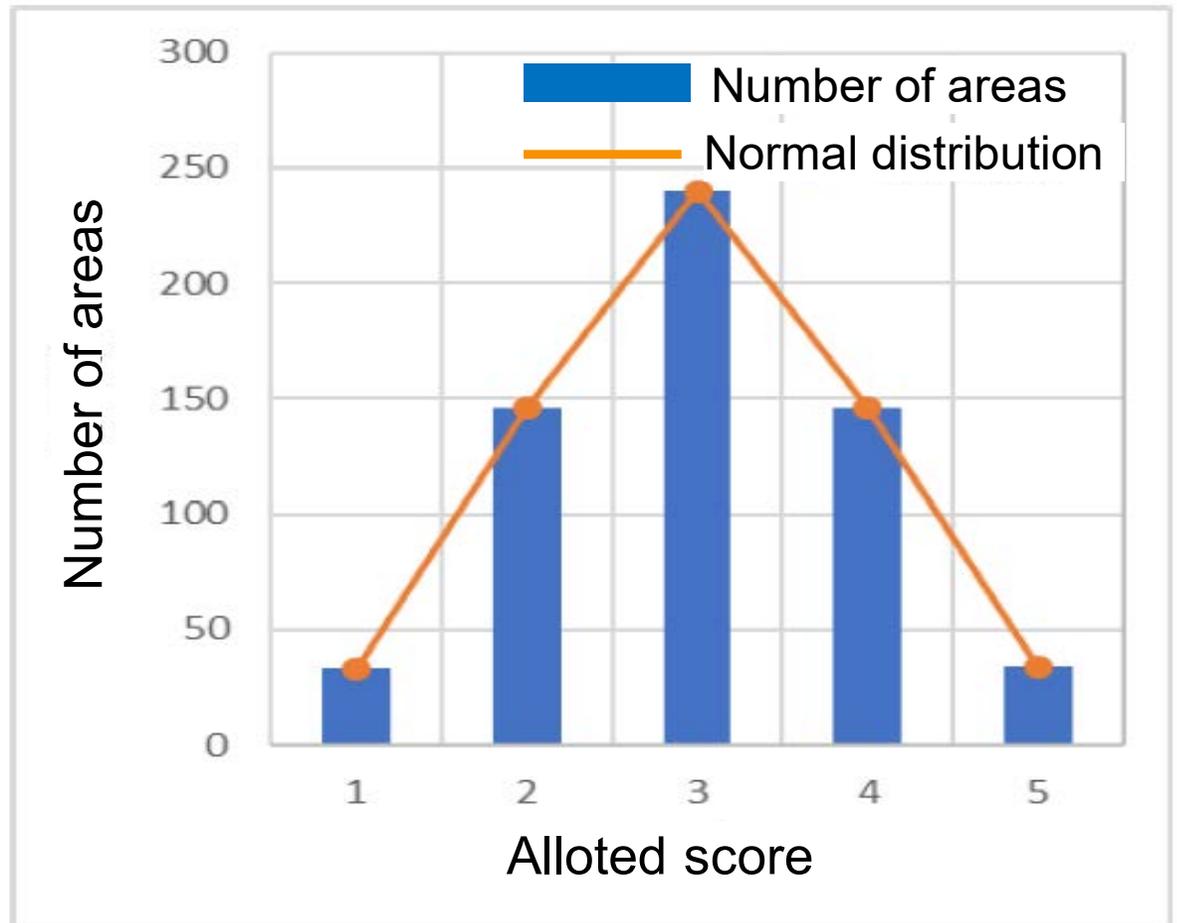
Evaluation of Flooding Risks

Summarizing results

Area No.	(2) Scoring for each index				(3) Alloted score after weighting		Total scores
	1: Underground shopping mall & underground facilities		2: House & household assets		1: Underground shopping mall & underground facilities	2: House & household assets	
	Number of faciliities	Score	Flooded asset sum (house flooding)	Score	0.094	0.04	…
Sakae 28-05	0	0	6087	4	0	0.16	2.299
Kohoku 41-15	0	0	1308	3	0	0.12	2.557
Sakae 30-16	3	4	7	1	0.376	0.04	2.217

High score = High flood risk

Creating Flooding Evaluation Sheets

- Priority ranking ➡
- Basic information ➡
- Flooding history etc ➡
- Other Important subjects etc ➡
- Main station etc ➡
- Assets etc ➡
- Counterplan,B/C etc ➡
- Other construction etc ➡

Areas that are assumed will flood

Conclusion

Safety and Security of Livelihoods of Citizens

Achieving Urban Planning Potent Against Disaster

Marching on to further strengthen flood control in Yokohama
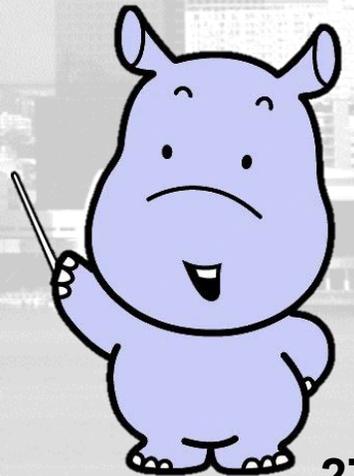
Thank you for your attention.