Climate Change Adaptation in Disaster Risk Management

JICA Handbook on Climate Change Adaptation in the Water Sector

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GEOSS Asian Water Cycle Initiative

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“Stationarity is Dead”
(Milly et al., 2008)

☺ Conventional Method of Water Planning

Assumption: rainfall pattern fluctuate within unchanging envelope of variability

☹ Under changing and uncertain climate

✓ Climate is changing

Return period (ex. 100-year flood or 10-year drought) is never foundation of planning

✓ Prediction possible, but with uncertainty

New Designing methods of water infrastructures are needed

River bank heights, reserve capacity, bridge heights etc.

Furthermore……

“Stationarity is Dead”

Is flood Control Philosophy Dead, as well?

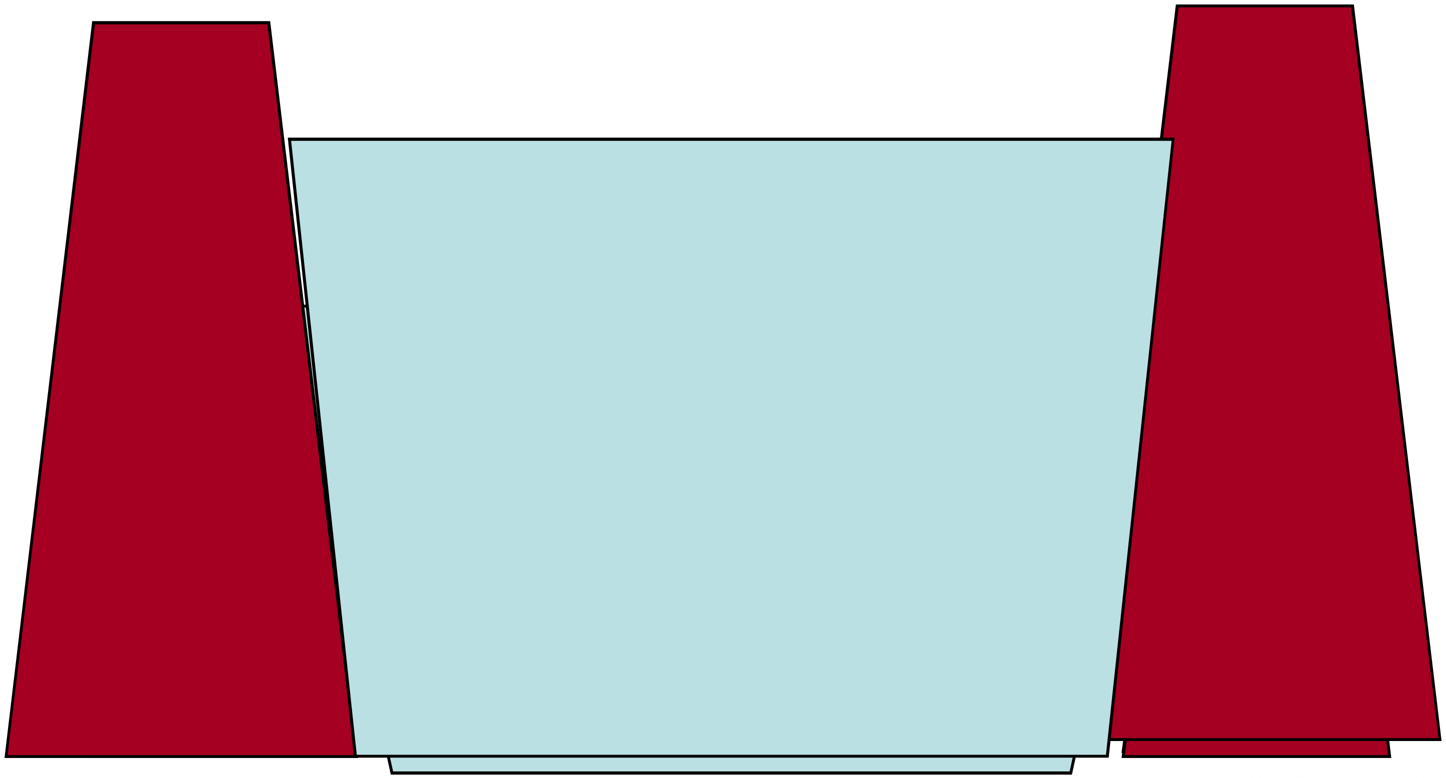
Source: MLIT

Can we continue to construct higher dykes according to increasing flood scale?

"Stationarity is Dead"

Is flood Control Philosophy Dead, as well?

Can we continue to construct higher dykes according to increasing flood scale?



Stationarity is Dead

Flood Control Philosophy is Dead as Well.

- Conventional philosophy is abandoned

  "Long liner bank system along river from river mouth to mountain"
- Proposed new philosophy

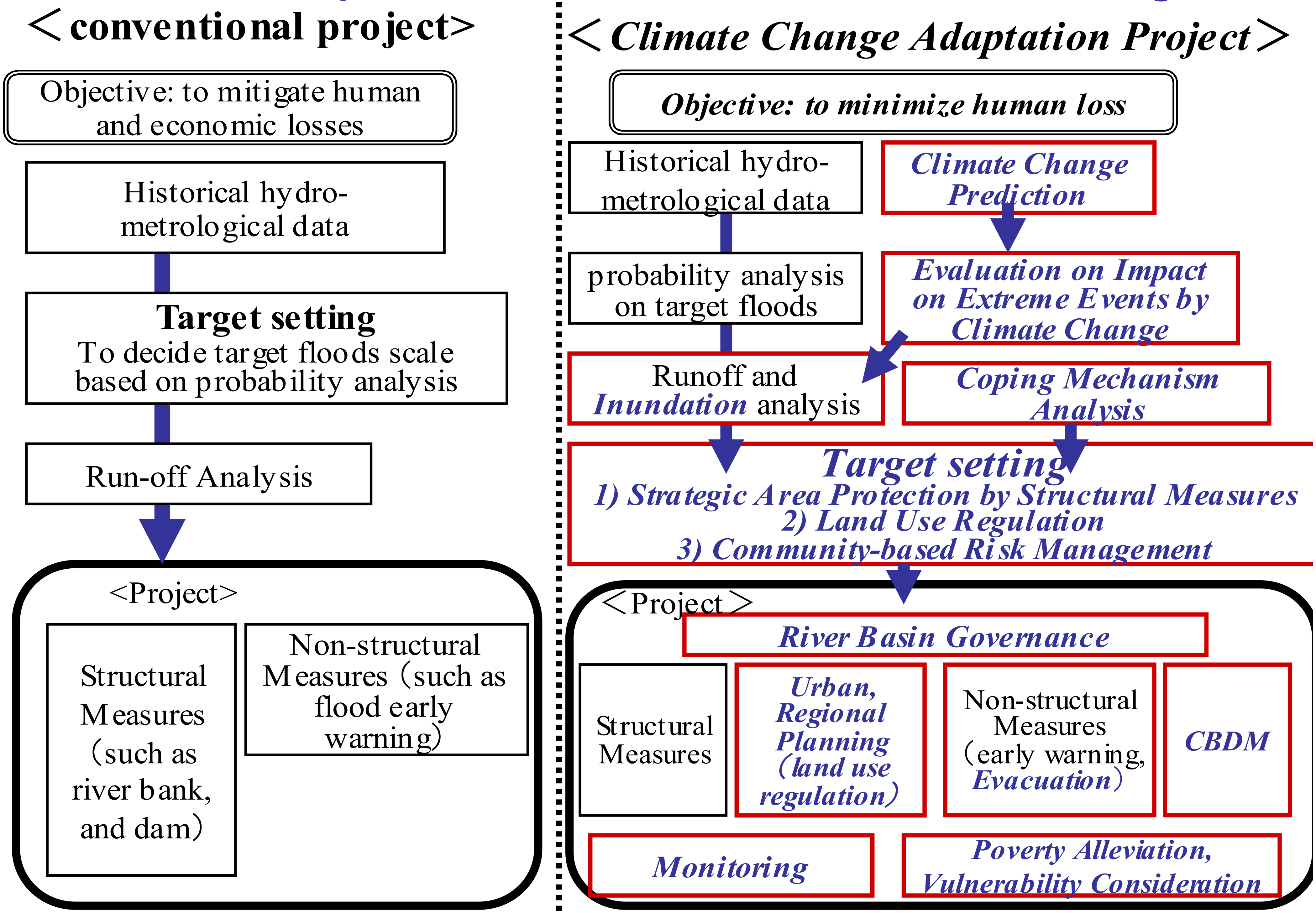
  "Multilayered measures in river basin"

  1) Step 1: Strategic area protect by structures

  2) Step 2: Urban planning and land use regulation for risk areas

  3) Step 3: CBDM

Proposed Method for CCA Planning



Flood Risk Management Under Changing Climate: Proposed Method

Sustainable society resilient to changes

1. to respond continuously changing climate
2. to plan and implement infrastructure projects through predicting future impacts with uncertainty
3. to change systems of water management according to developing technology for prediction and adaptation of climate change

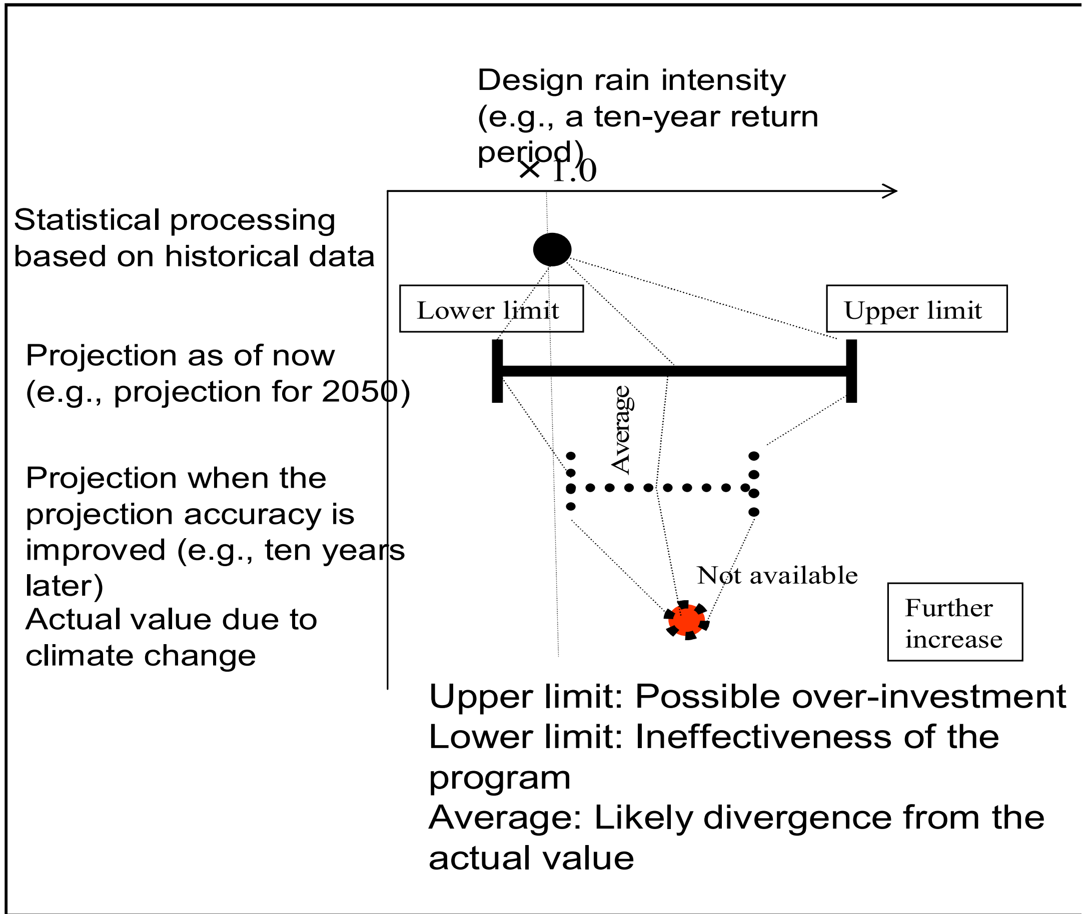
1. five basic concepts for an approach to coping with a changing and uncertain climate resiliently and sustainably

1. **Human security**: Focusing on individuals, particularly the most vulnerable
2. **Engagement with the society**: Engaging with the society as a whole, including policymakers and decision makers
3. **Building a sustainable adaptive society**: resiliently cope with a changing climate whose prediction entails uncertainty
4. **Disaster risk management**: with the focus on the society's vulnerabilities, especially associated with urbanization, and adaptive capacity
5. **"Zero victim" goal of flood control**:
   (i) protecting critical areas using structures,
   (ii) no settlement in disaster hazard areas, and
   (iii) coping with unavoidable inundation with CBDM

2. Forecasting extreme events

How to use GCM data in formulating a project and handling projecting uncertainties.

- High-resolution model
- Down-scaling
  - Dynamic
  - Statistical
- Ensemble



3. Assessing damage and impacts.

1. Setting: target years, return period, rainfall
2. existing coping mechanisms
3. impact assessment methods
   - inundation analysis: simulation, or interview
   - impact assessment

4. Climate change adaptation measures

- Governance at river basin level
  - Involvement of various sectors, organizations, stakeholders
  - Need for consensus building and responsibility sharing
- Flood Risk Management
  - Structure measures
  - Non-structural measures: early warning and evacuation
  - Land use regulation
  - Community-based Disaster Management
- Water use & environment: Strengthening IWRM
- Coastal protection: Study carefully because of high costs and projection challenges
- Capacity Development
- Monitoring
- Poverty alleviation and consideration on vulnerability group

5 need for capacity development

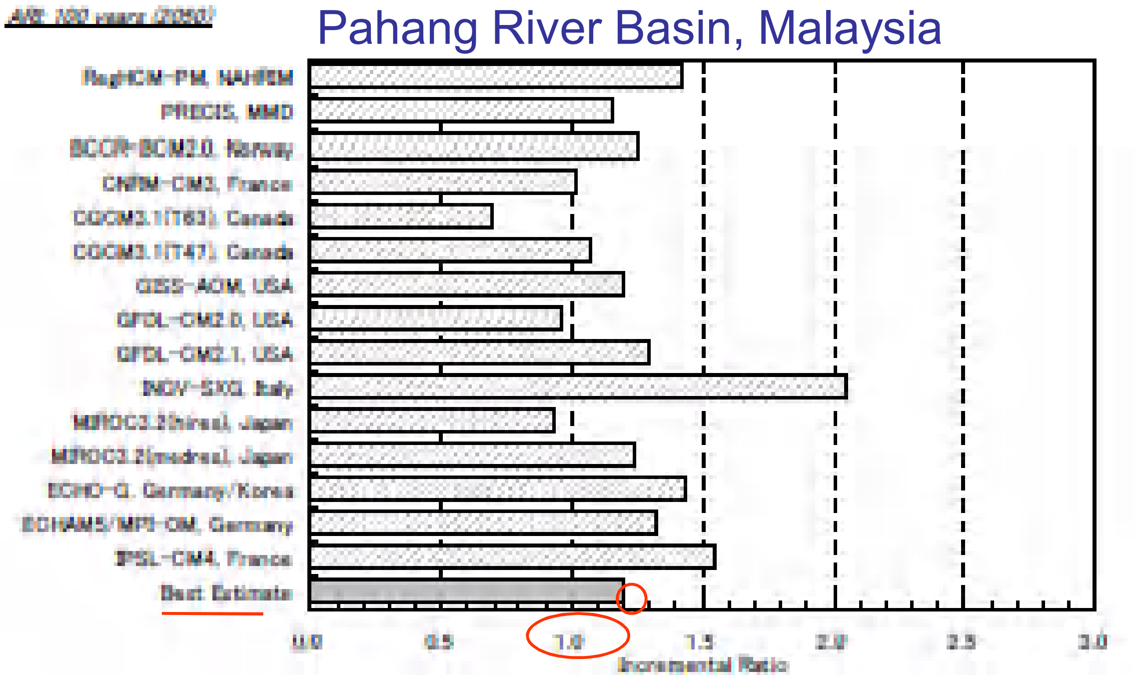
developing countries will be able to better cope with changing by themselves:

- climate change, and
- technological development

Climate change prediction Impact on Extreme Event

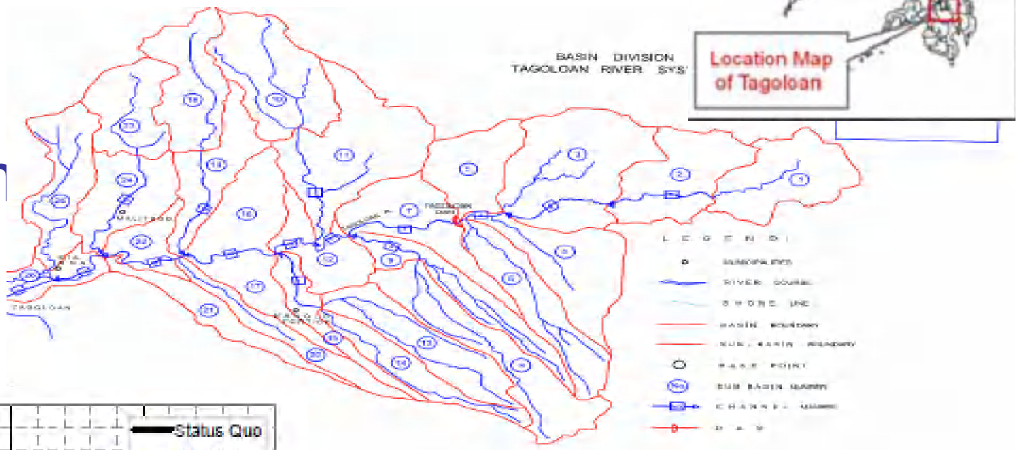
- Target year: Near-term 25-30 years
  - Comparatively low uncertainty, social factors not substantially affect climate
- Down-scaling
  - Statistical, Dynamic
  - Multi-model ensemble of GCM

Pahang River Basin, Malaysia



Case Study 1: Tagoloan River Basin, the Philippines

- Catchments 1,778km2
- Precipitation 1,500-2,000m



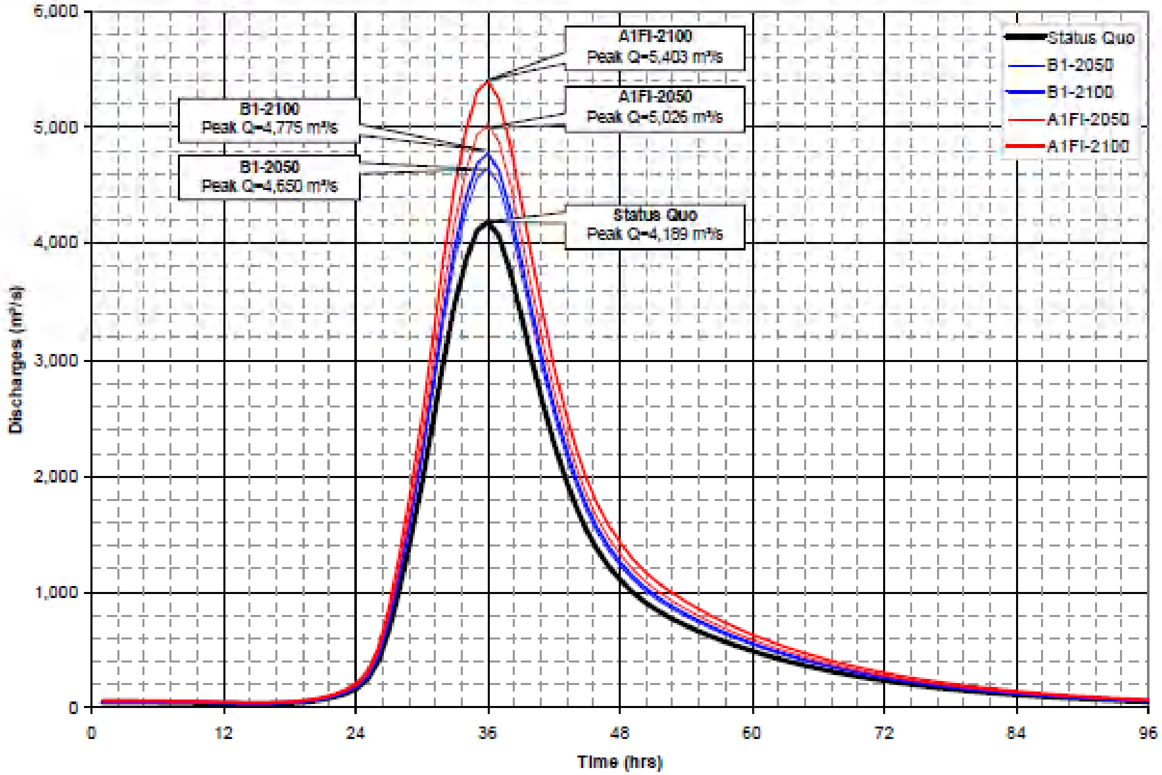
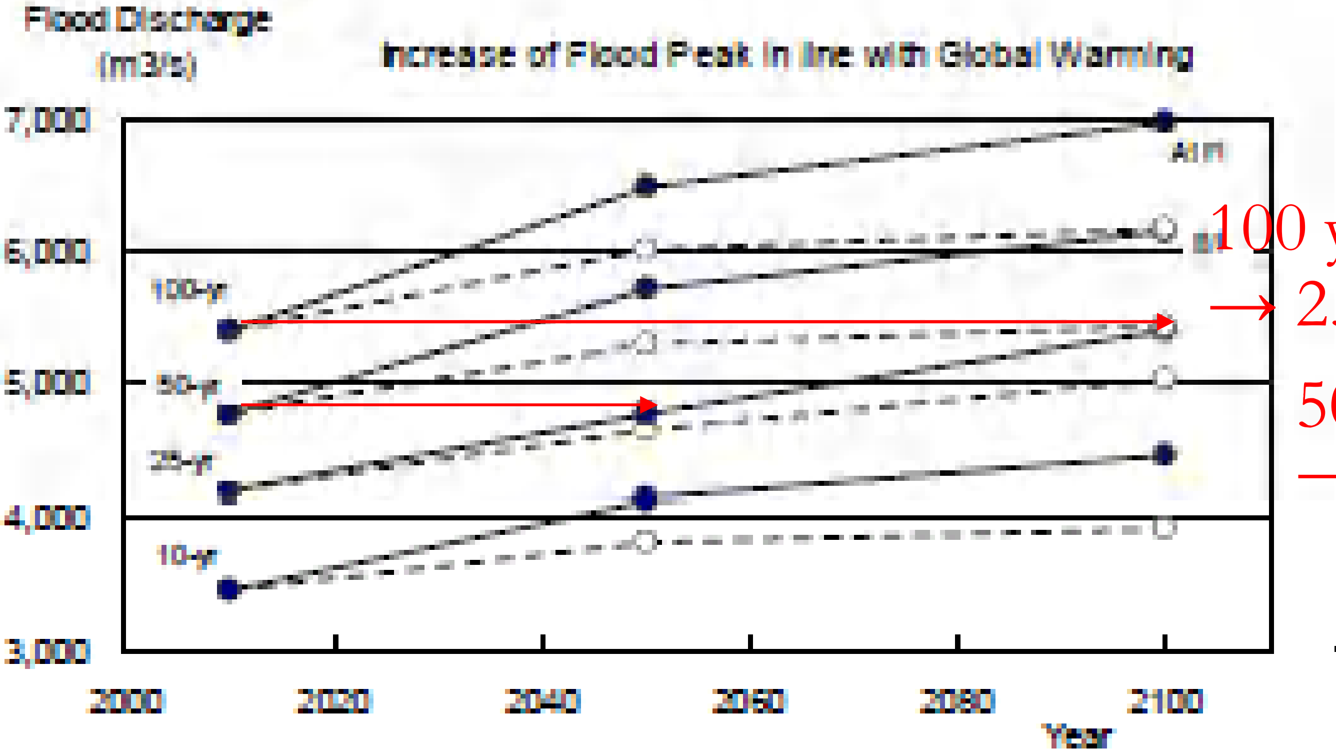


Figure R 10.16 Future 25-yr Probable Design Hydrographs

25-yr return period
4,200 in present
4,650-4,800 in 2050
5,000-5,300 in 2100



100 yrs flood
→ 25-50yr flood in 2100

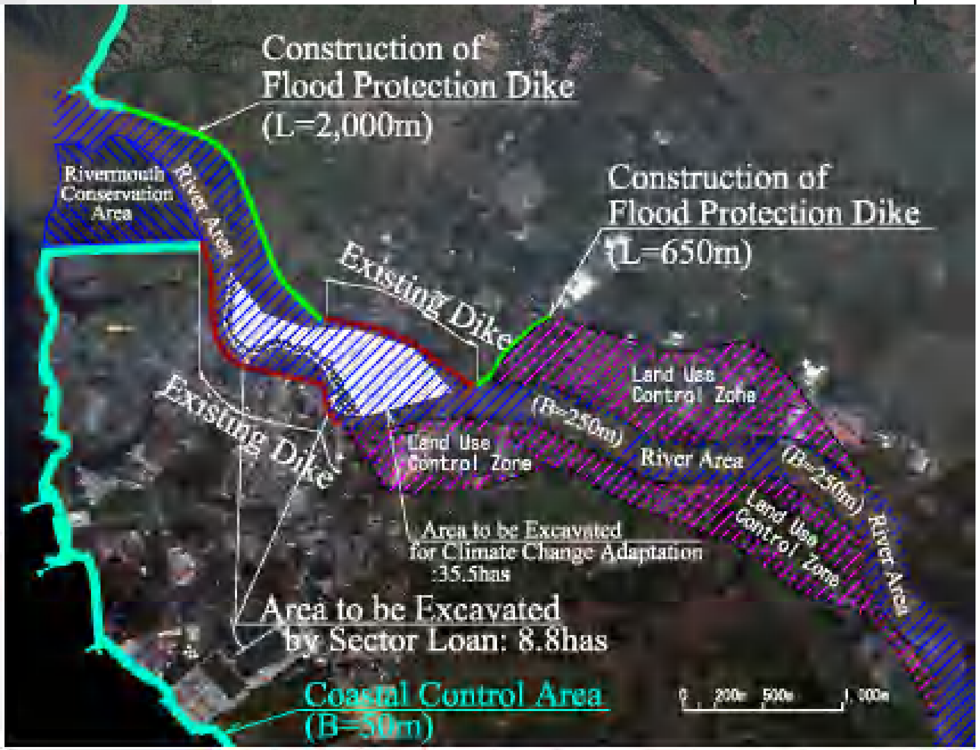
50 yrs flood
→ 25yr flood in 2050

Scenario		rainfall intensity (%)	Return period (year)	5yr	10yr	25yr	50yr	100yr	Probable Flood Discharge (m3/s) 25yr	Probable Flood Discharge (m3/s) 50yr
Status quo		-		125	142	164	181	198	4190	4770
A1F1	2050	11		150	170	197	217	237	4780	5720
	2100	14		161	183	211	233	255	5400	6150
B1	2050	20		138	157	182	200	219	4650	5290
	2100	29		142	162	187	206	225	5030	5430

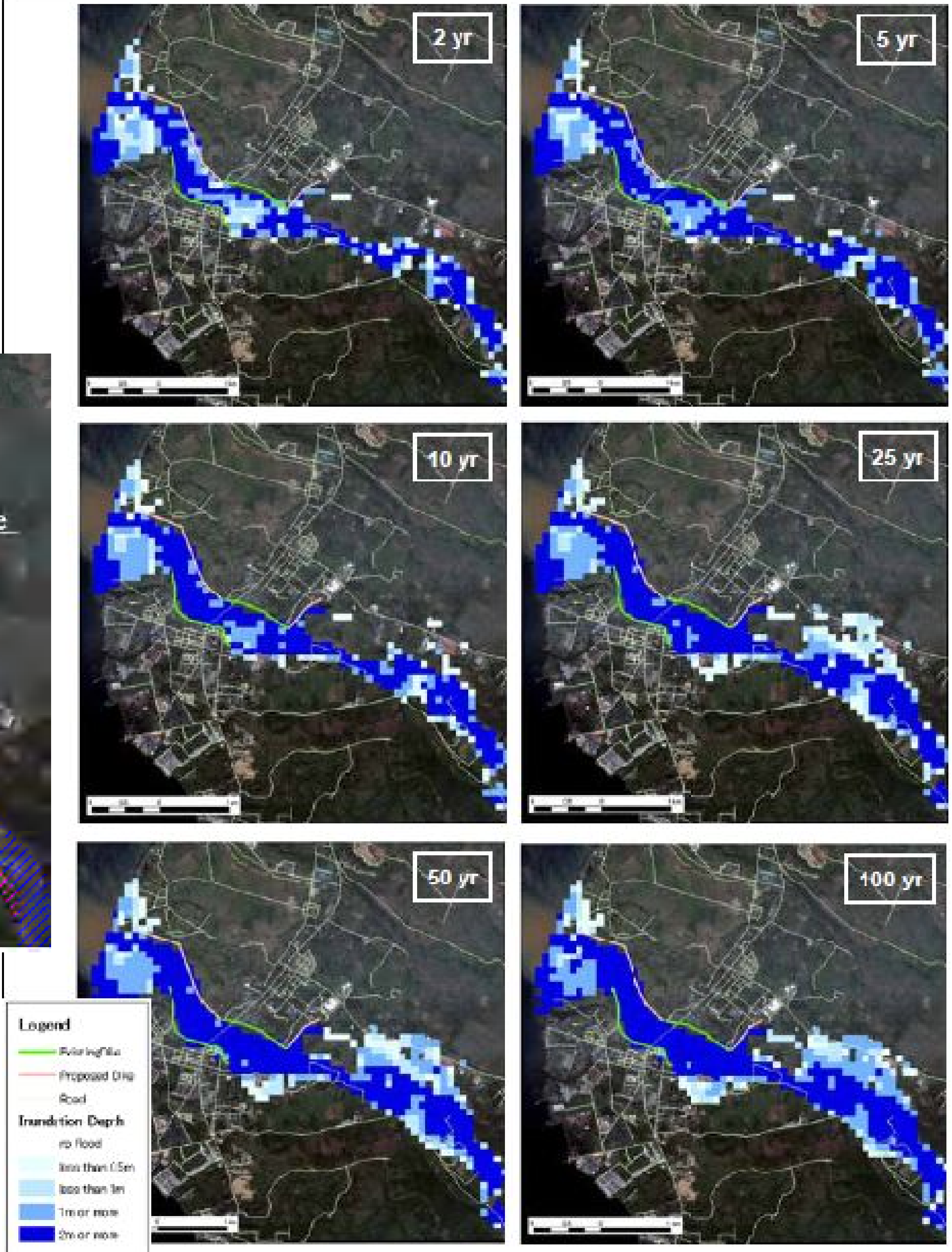
Revising Plan

Original MP

Revised MP



Construction of
Flood Protection Dike
(L=2,000m)
Rivermouth Conservation Area
River Area
Construction of
Flood Protection Dike
(L=650m)
Existing Dike
Existing Dike
Land Use Control Zone
Land Use Control Zone
(B=250m)
River Area
(B=250m)
Land Use Control Zone
River Area
Area to be Excavated
for Climate Change Adaptation
:35.5has
Area to be Excavated
by Sector Loan: 8.8has
Coastal Control Area
(B=50m)



2 yr
5 yr
10 yr
25 yr
50 yr
100 yr
Legend
Proposed Dike
Road
Inundation Depth
no flood
less than 0.5m
less than 1m
1m or more
2m or more

Case Study 2: Cavite,the Philippines

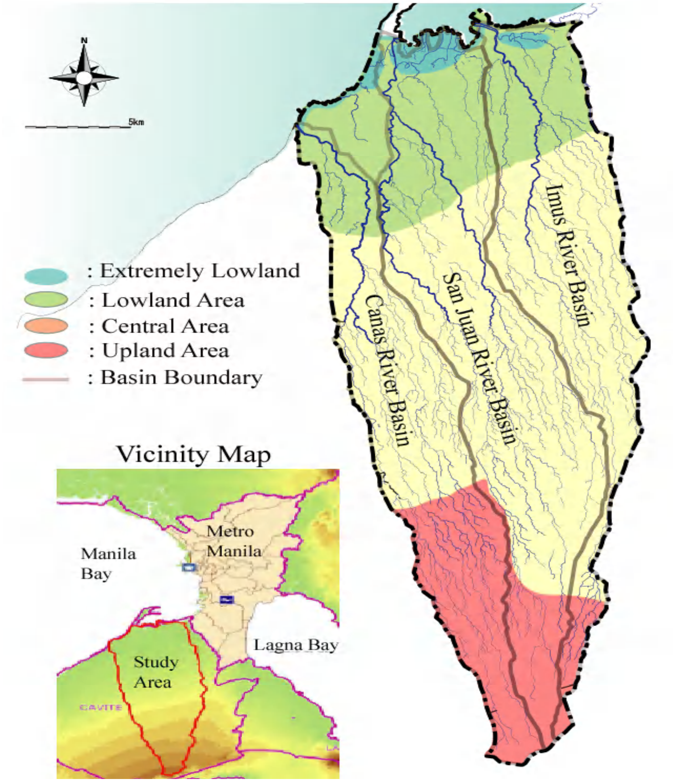
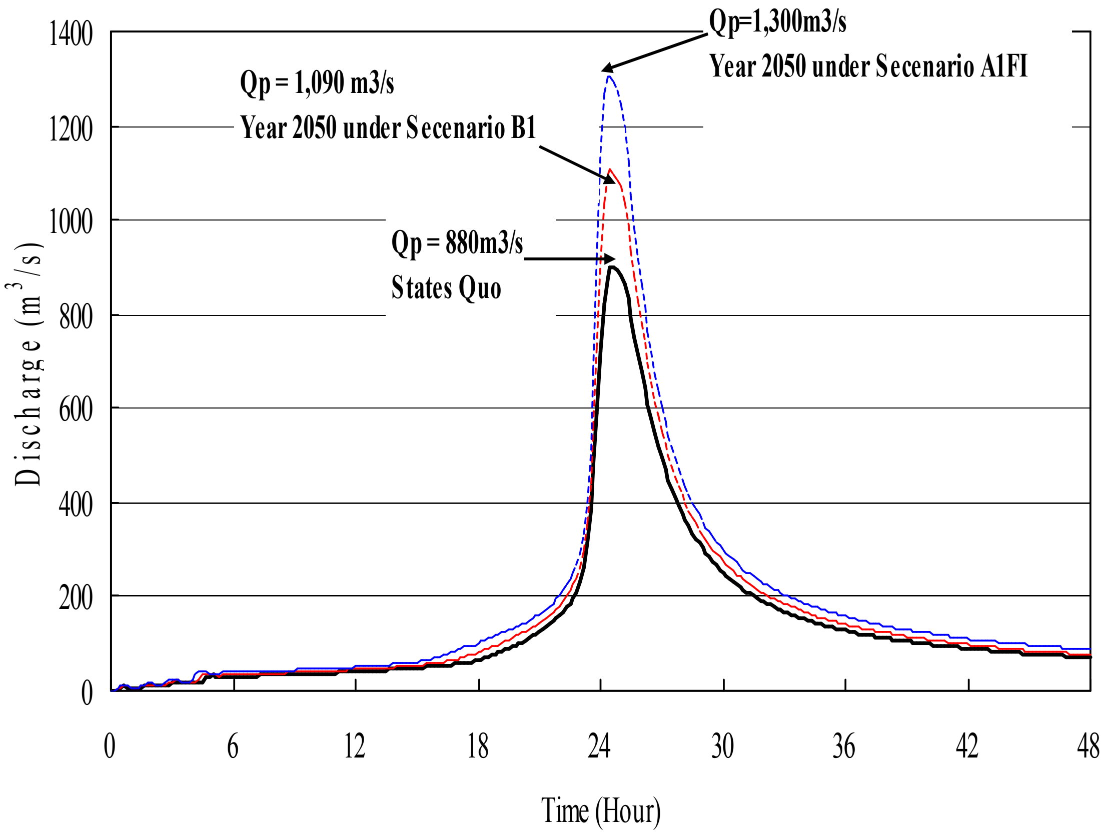
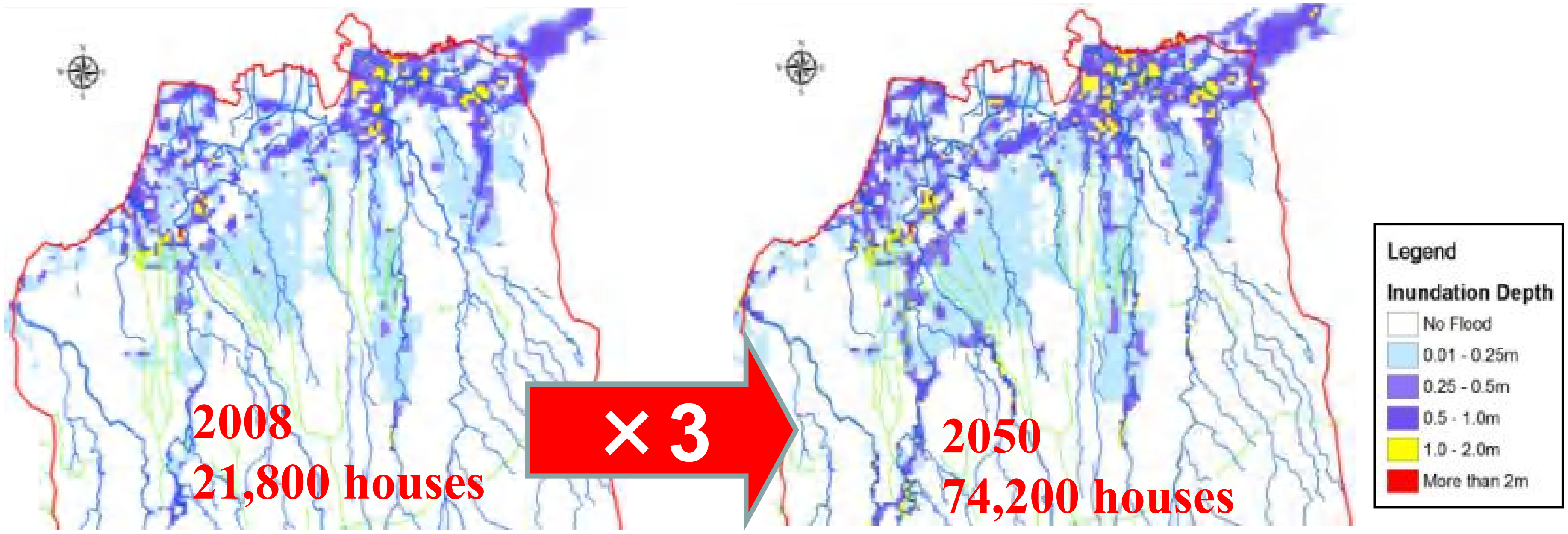


Fig. 1 General Map of Study Area



River Basin	Catchments Area (km2)	River Length (km)
Imus	115.5	45.0
San Juan	147.76	43.4
Canas	112.32	42.0
Residual	32.84	-
Total	**407.4**	

危険地域の家屋数
Houses at risk area



Case No.	Scenario of Climate Change	Urbanized Ratio	Probable Flood Inundation Area (km^2)			Number of Houses/Buildings Inundated (thousand houses)		
			Flood Depth below 1m	Depth above 1m	Total	Flood Depth below 1m	Flood Depth above 1m	Total
1	Status Quo	26%*	31.51	1.05	32.56	20.1	1.7	**21.8**
2	States Quo	43%**	35.82	1.50	37.32	31.4	2.9	34.4
3	In 2050 under B1 Scenario		41.10	2.52	43.62	35.5	4.4	39.9
4	In 2050 under A1FI Scenario		44.64	3.54	48.18	38.4	5.9	44.3
5	States Quo	65%***	41.05	2.45	43.50	56.4	7.2	63.6
6	In 2050 under B1 Scenario		43.92	2.97	46.89	60.1	8.5	68.6
7	In 2050 under A1FI Scenario		**47.27**	**3.98**	**51.25**	**63.0**	**11.2**	**74.2**

multiplication of CC and Urbanization

都市化　Urbanization

気候変動
Climate Change

表面流
Surface flow

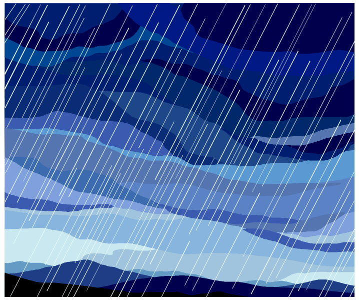
雨
Rain

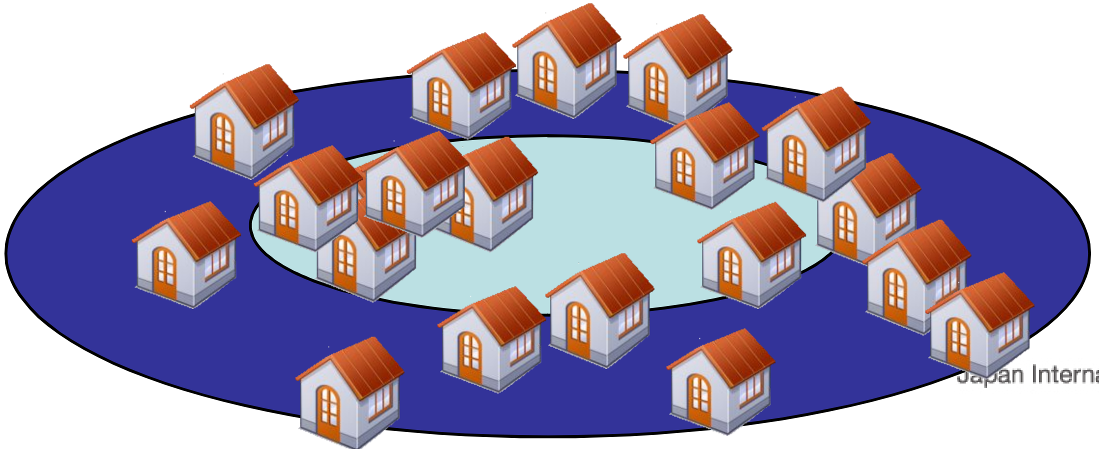
海面上昇
Sea Level

危険地域の家屋
Houses at risk area

洪水
Floods volume

危険地域
Risk area

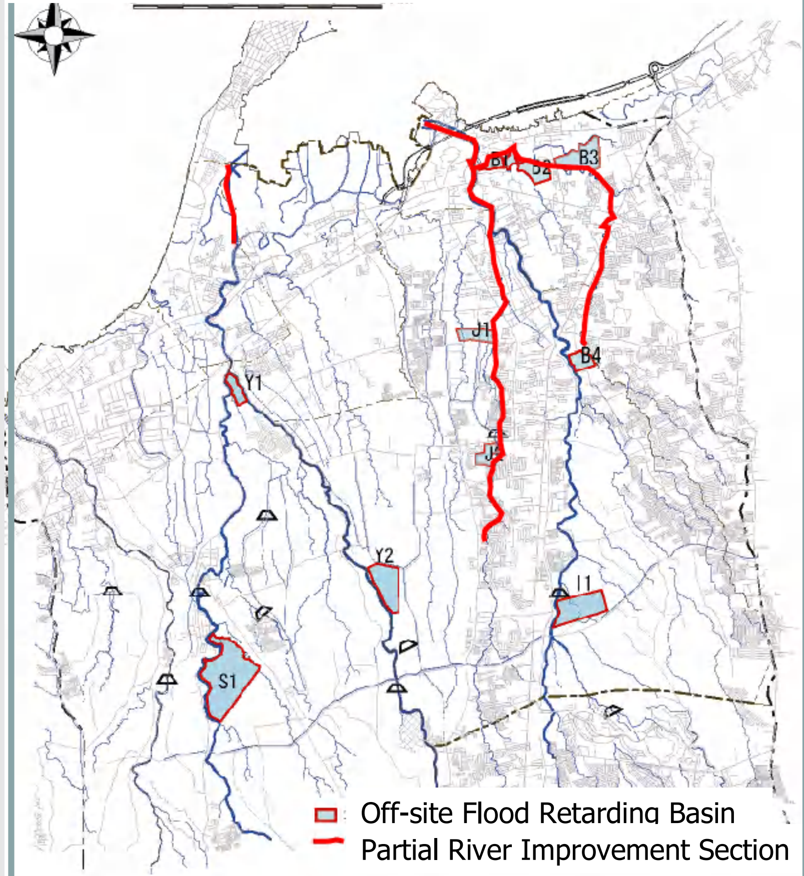




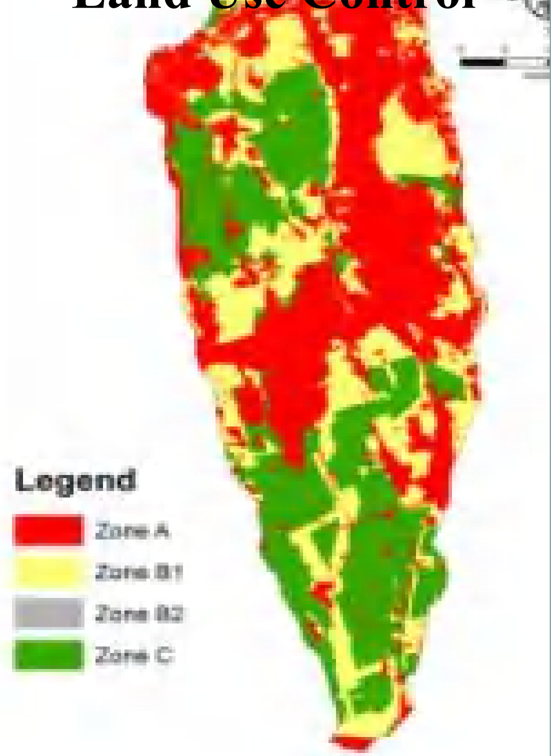
適応策検討　Climate Change Adaptation

遊水地計画を将来拡張する可能性
→都市計画に開発抑制地域として線引き

１．河川工事・遊水地
River improvement works



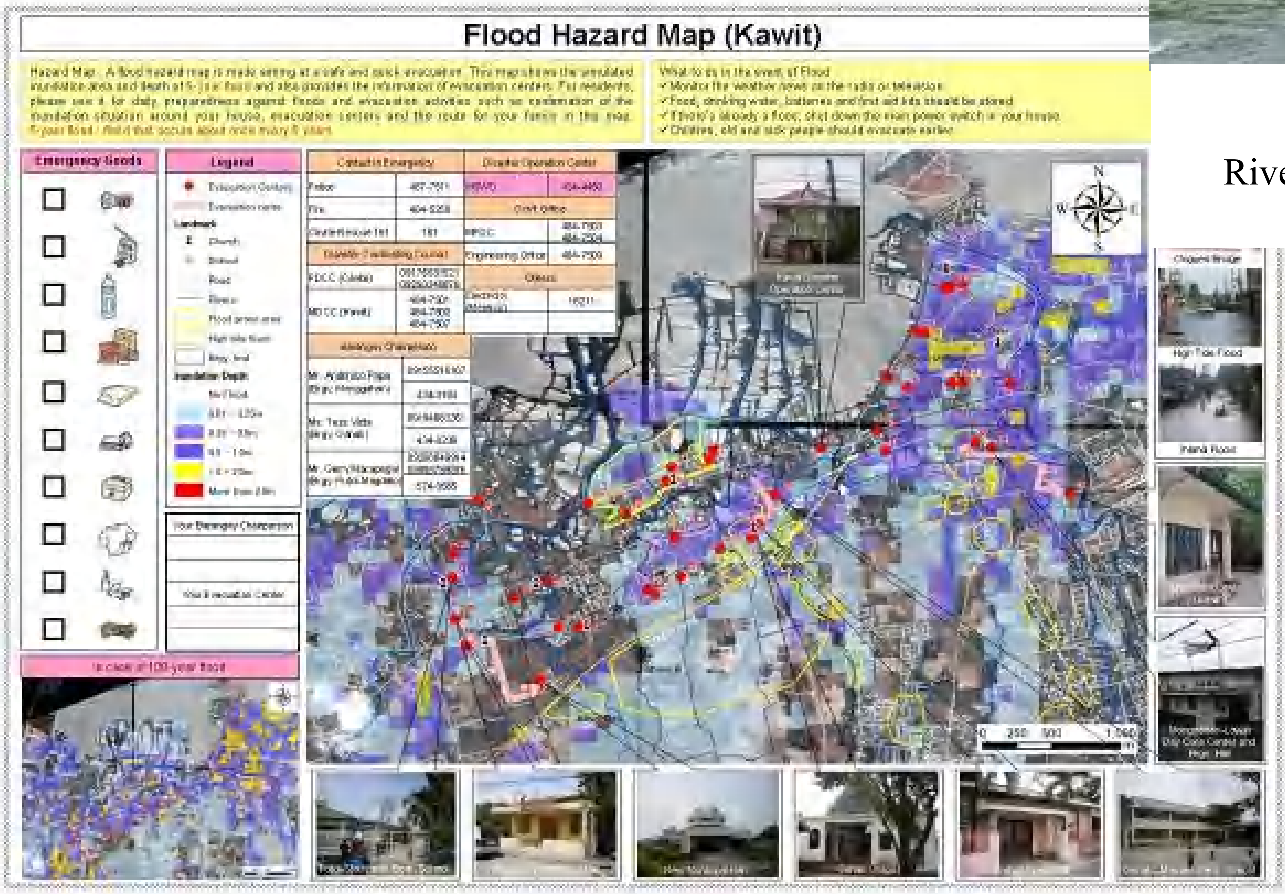
2.土地利用規制
Land Use Control



3. 調整池Retarding Basin in Urban area

適応策　Climate Change Adaptation
ソフト対策　Software measures

ハザードマップ



簡易観測

River Water Level Indicator for Flood Warning and Evacuation

適応策　Climate Change Adaptation

コミュニティ防災　Community based disaster management

適応策　Climate Change Adaptation

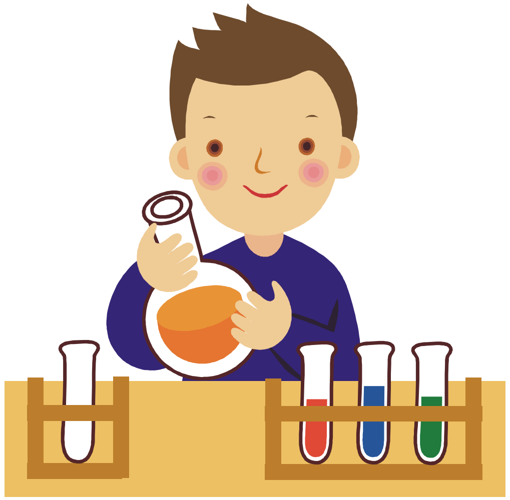
コミュニティ防災　Community based disaster management

5. conclusion

- Startionarity is dead, flood control philosophy either?
- JICA's Handbook for Climate Change Adaptation in Water
- Proposed method of CCA in flood risk management is applied in the Philippines
- Various local solutions are required for adaptation

JICA handbook

Ver.0 was produced



Ver.1 will be issued at the end of FY2010

Comments are welcomed

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Climate Change Impact

Statistical Down Scaling

- 12 GCM IPCC4
- Scenarios
  - A1F1(pesimistic)
  - B1 (optimistic)
- max. daily rainfall in PHI

$$\frac{(2080\text{-}2100)}{(1980\text{-}2000)}$$

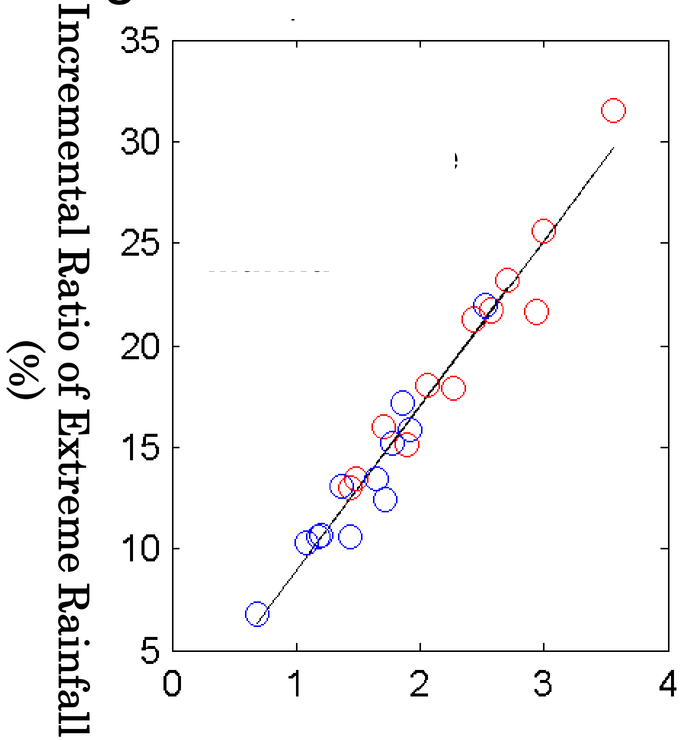
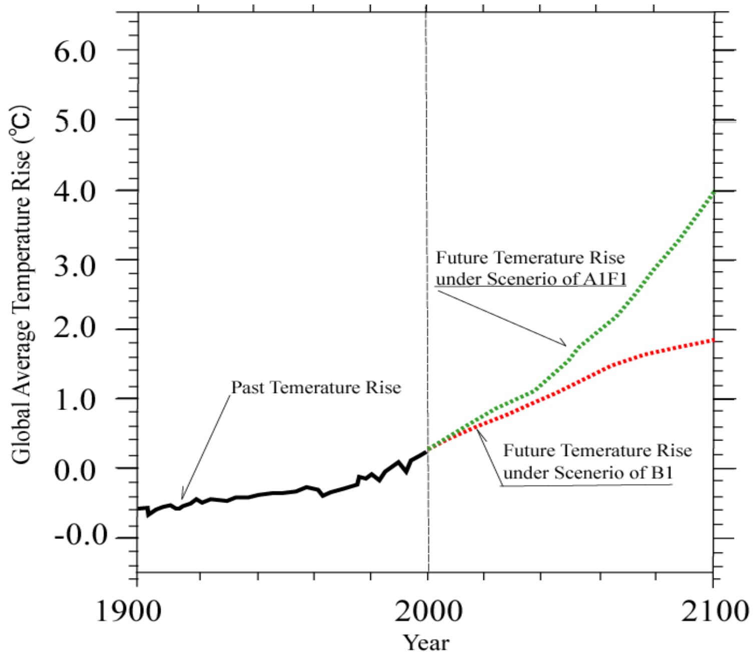


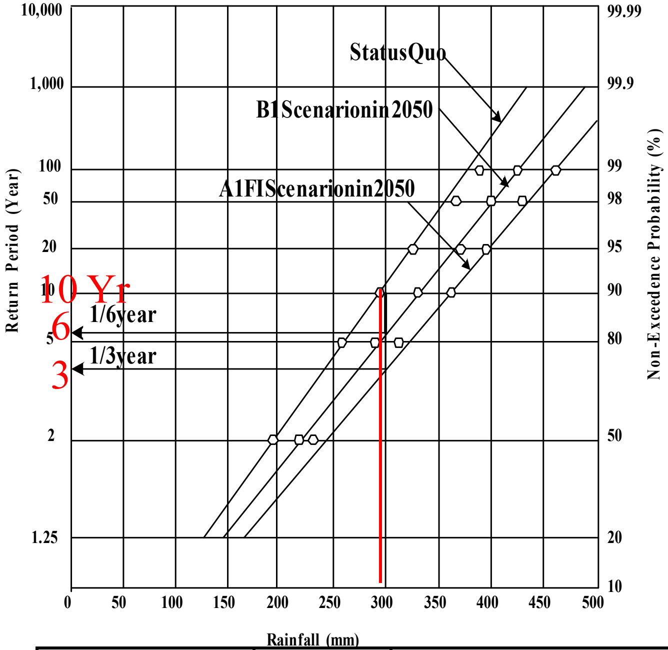
Fig.7 Relation between Local Average Temperature Rise and Incremental Rate of Storm Rainfall in Philippines



Scenario	Year	Temperature Rise(℃)	Increase Rate of Storm Rainfall Intensity (%)
B1 scenario	2050	1.1	11
	2100	1.5	14
A1FI Scenario	2050	2.3	20
	2100	3.5	29

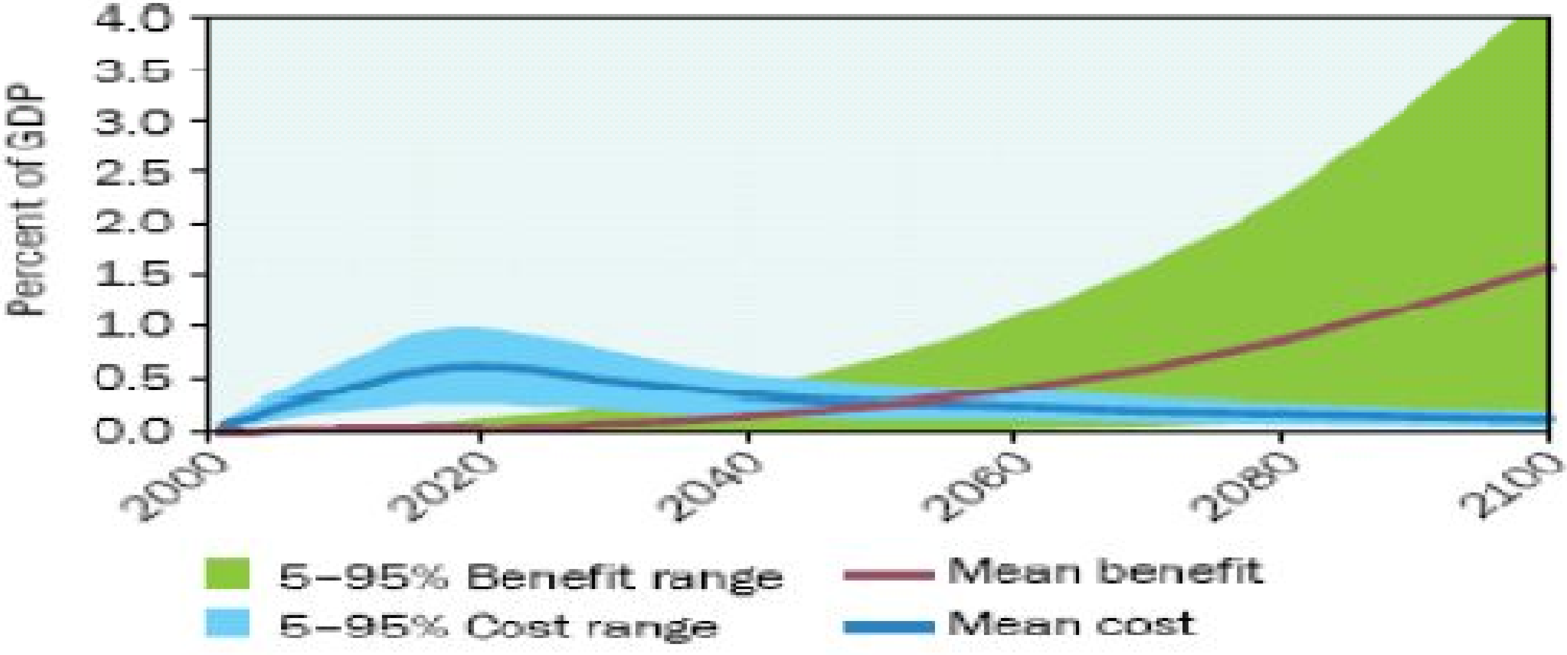
Climate Change Impact

Relationship between Two-day Storm Rainfalls and Recurrence Probabilities



Scenario	Year	Increase Rate of Storm Rainfall(%)	Probable 2-day Storm Rainfall (mm)					
			2-year	5-year	10-year	20-year	50-year	100-year
Status Quo	2003	-	191	258	**295**	326	360	383
B1	2050	11	212	286	327	362	400	425
	2100	14	218	294	336	372	411	437
A1FI	2050	20	229	310	354	391	432	460
	2100	29	246	333	380	421	465	494

Figure H13. Cost and Benefit of Adaptation



Note: 'mean' indicates the average outcome of the simulations and the range of estimates from the 5th to the 95th percentile is shaded area. Benefit in terms of avoided damage is based on A2 scenario.

Source: ADB study team.

Stern: better spend 1% GDP now, than 5% GDP later!

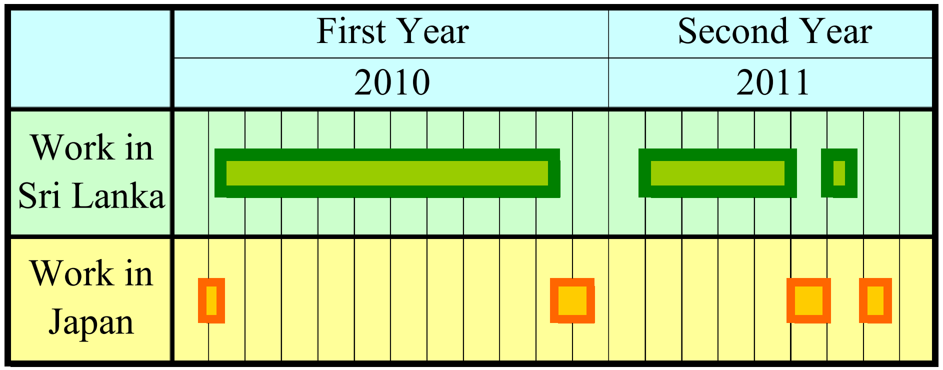
Climate change prediction
Study in South Western Sri Lanka

Study Area

River Basin	C.A.
Kalu River basin	2,719km^2
Kelani River basin	2,292km^2
Gin River basin	932km^2
Nilwara River basin	971km^2

Study Schedule

21 months
(from January 2010 to September 2011)



Climate change prediction
Study in South Western Sri Lanka

(1) Data Collection

- Projected Rainfall Data from CMIP3
- Projected Rainfall Data of GCM20 (1979-1998, 2080-2099)
- Recorded Rainfall Data in Project Area
- Mesh Rainfall data from APHRODITE daily precipitation

(2) Examination of Appropriateness of **GCM20** by Comparison with CMIP3 Rainfall Data

(3) **Bias Correction** and **Statistic Downscaling**

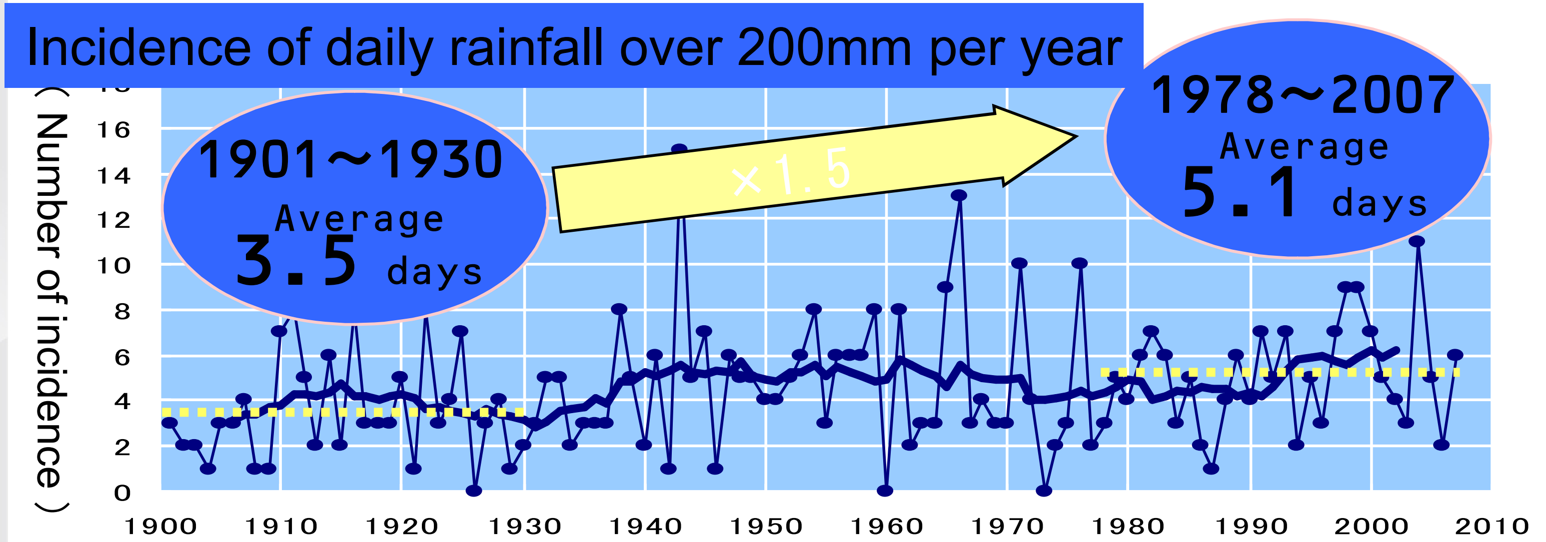
(4) Evaluation of Flood Risk (Hydrological and Hydraulic Analyses)

Note: CMIP3: Phase 3 of Coupled Model Intercomparison Project
GCM20: General Circulation Model (20km grid)
APHRODITE: Asian Precipitation-High Resolved Observational Data Integration Towards Evaluation of the Water Resources

Recent change on Climate in Japan

国土交通省

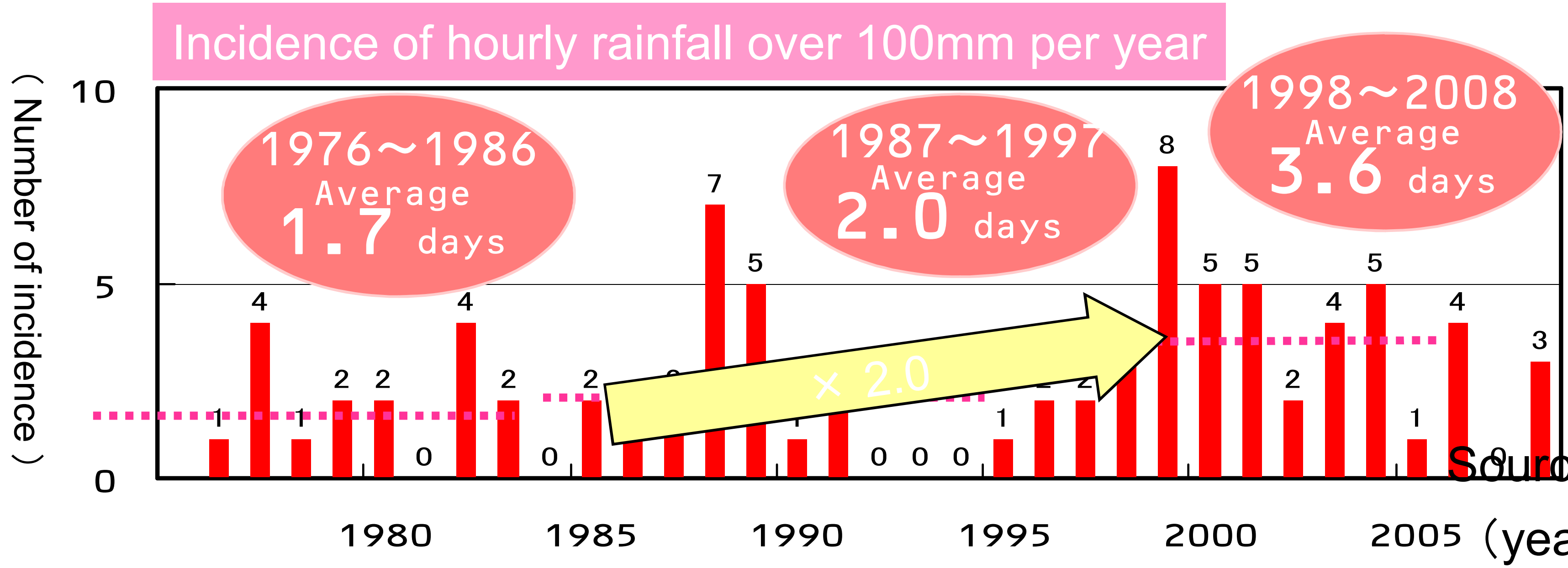
Daily rainfall over 200mm is significantly increasing



Source: JMA

（year）

Hourly rainfall over 100mm is increasing



Source: JMA

Projection of future Climate

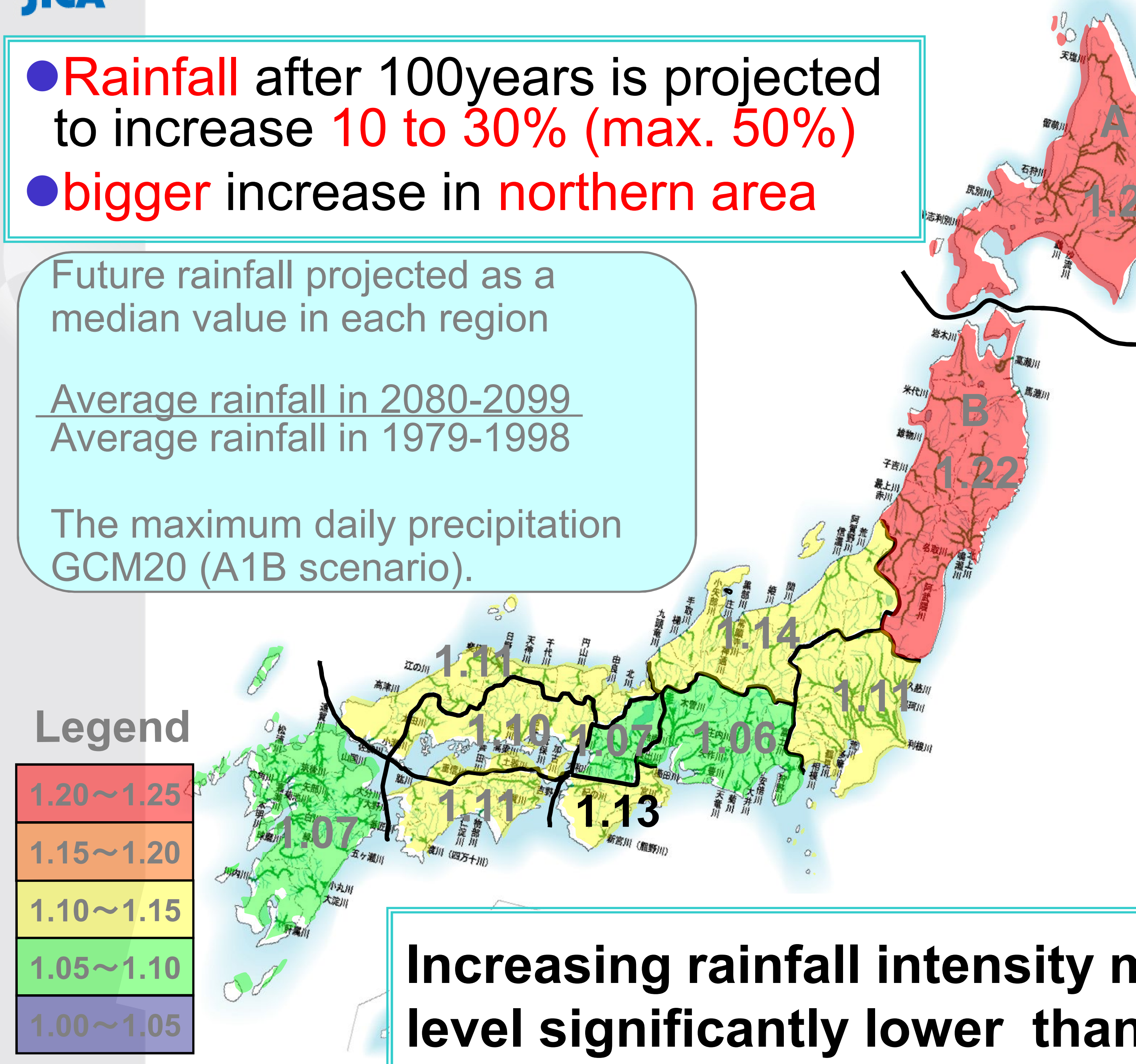
●Rainfall after 100years is projected to increase 10 to 30% (max. 50%)

●bigger increase in northern area

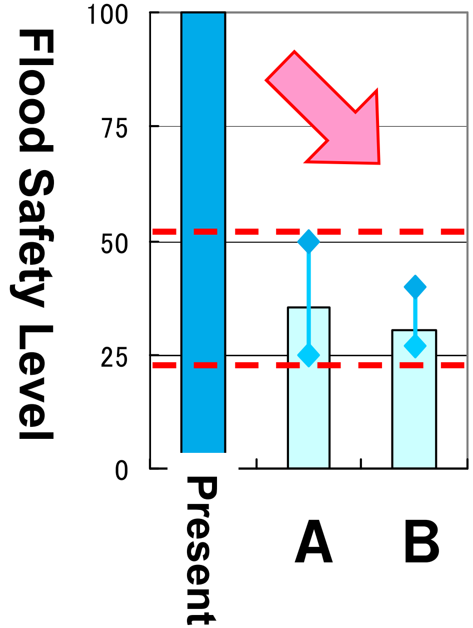
Future rainfall projected as a median value in each region

$$\frac{\text{Average rainfall in 2080-2099}}{\text{Average rainfall in 1979-1998}}$$

The maximum daily precipitation GCM20 (A1B scenario).



Decline of flood safety level



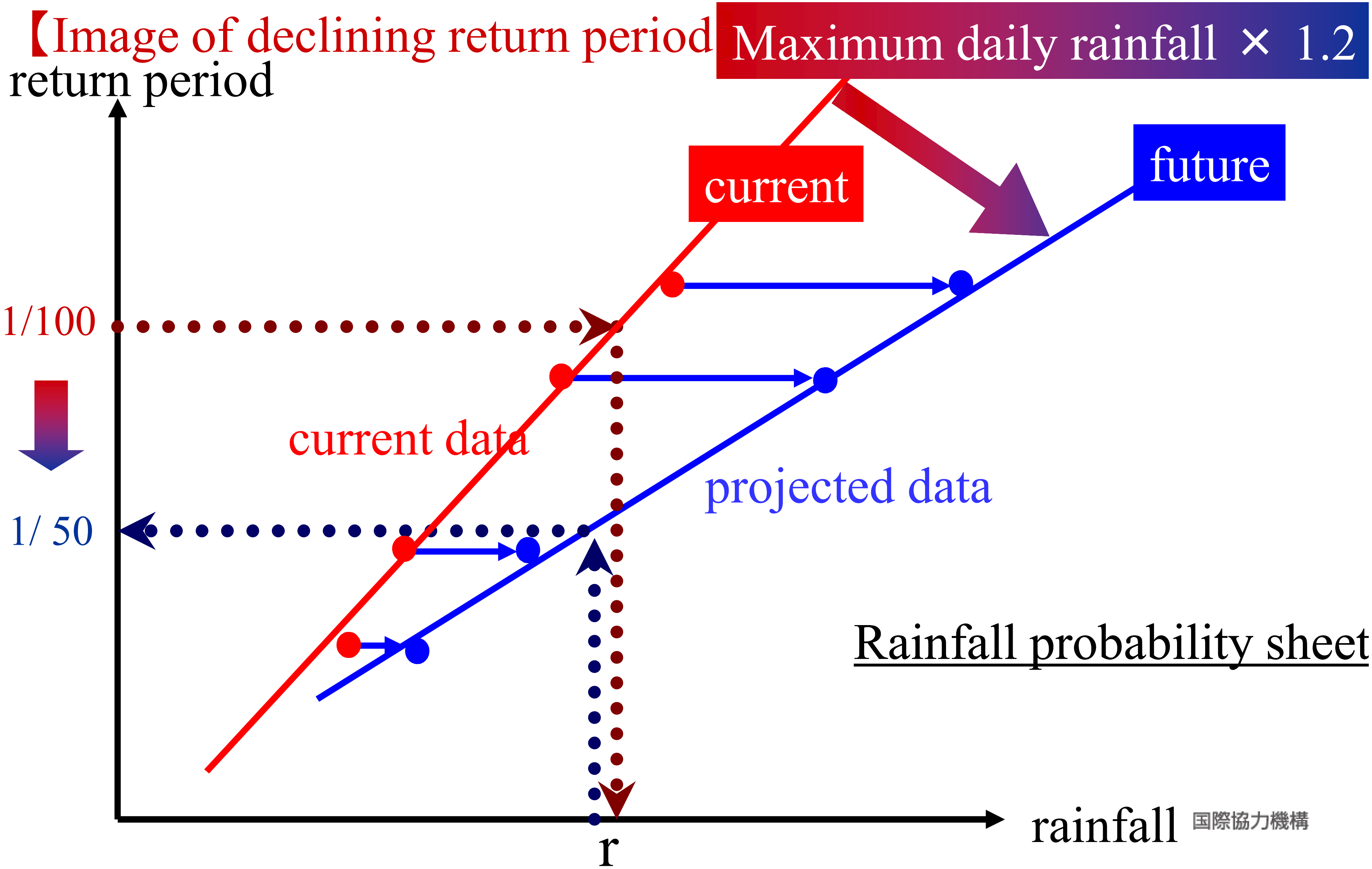
Increasing rainfall intensity make flood safety level significantly lower than present

Declining safety level against floods

Return period of flood is declining by increasing rainfall.

確率年の減少

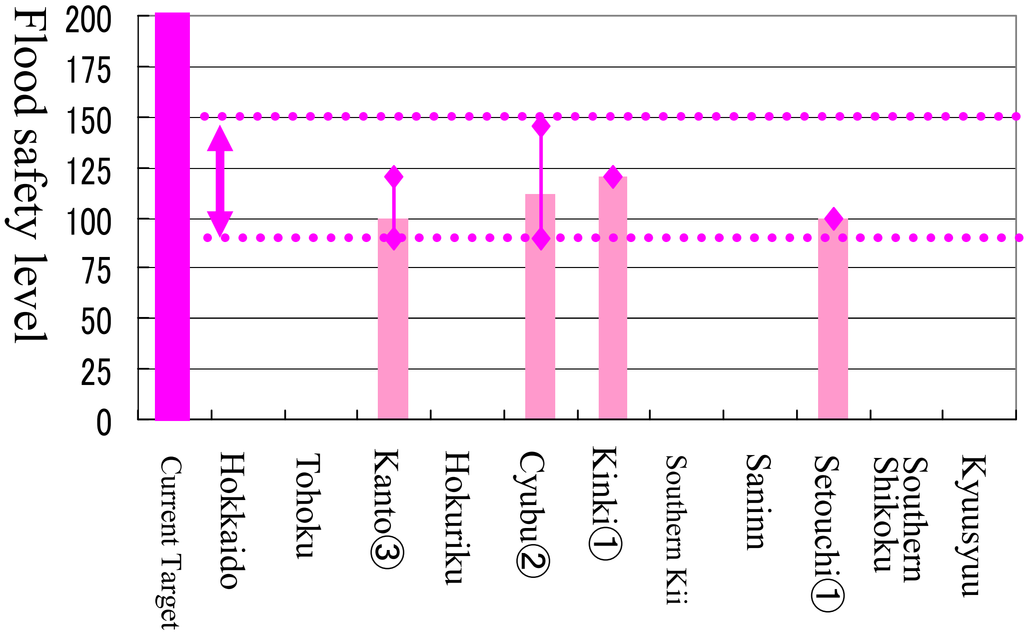
【Image of declining return period

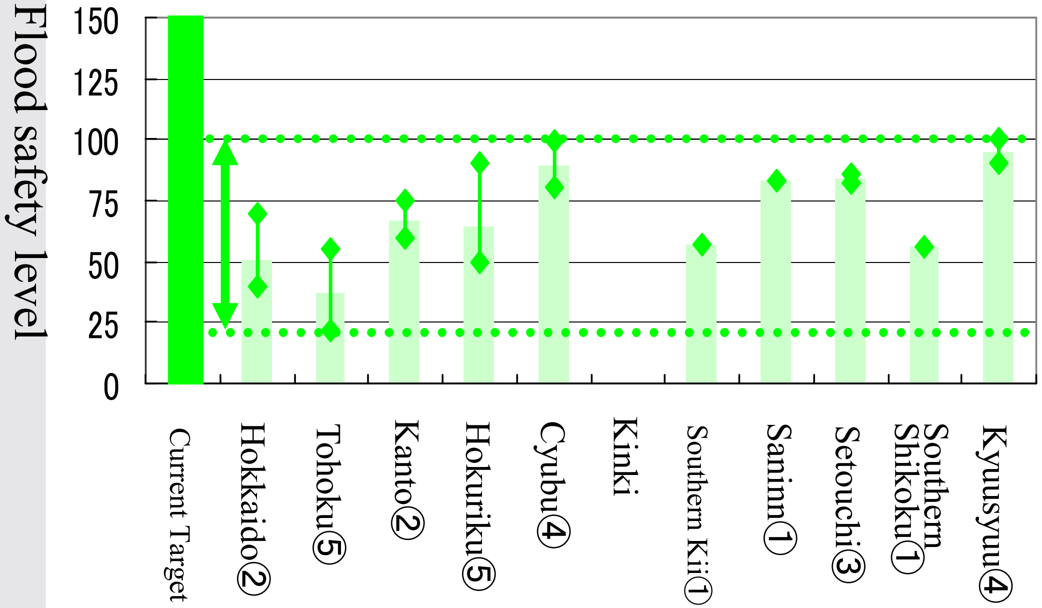


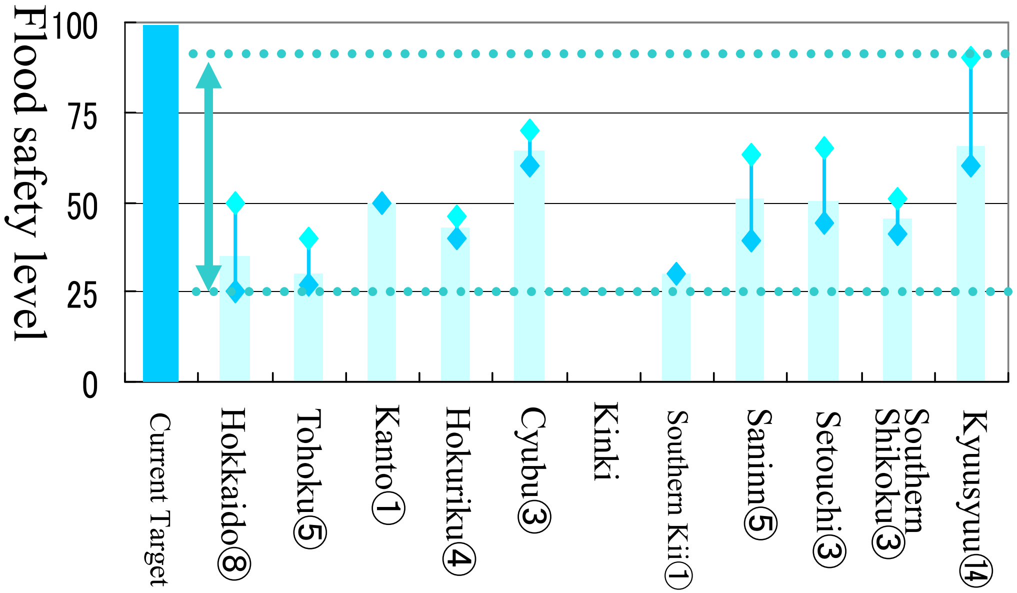
Declining safety level against floods　安全性の低下

Impact for flood safety level after 100 years

Region	1/200 (CurrentTarge)		1/150 (CurrentTarge)		1/100 (CurrentTarge)	
	Future flood safety level (annual exceedance probability)	Number of river system		Number of river system		Number of river system
Hokkaido	－	－	1/40～1/70	2	1/25～1/50	8
Tohoku	－	－	1/22～1/55	5	1/27～1/40	5
Kanto	1/90～1/120	3	1/60～1/75	2	1/50	1
Hokuriku	－	－	1/50～1/90	5	1/40～1/46	4
Cyubu	1/90～1/145	2	1/80～1/99	4	1/60～1/70	3
Kinki	1/120	1	－	－	－	－
Southern Kii	－	－	1/57	1	1/30	1
Saninn	－	－	1/83	1	1/39～1/63	5
Setouchi	1/100	1	1/82～1/86	3	1/44～1/65	3
Southern Shikoku	－	－	1/56	1	1/41～1/51	3
Kyusyu	－	－	1/90～1/100	4	1/60～1/90	14
All Japan	1/90～1/145	7	1/22～1/100	28	1/25～1/90	47





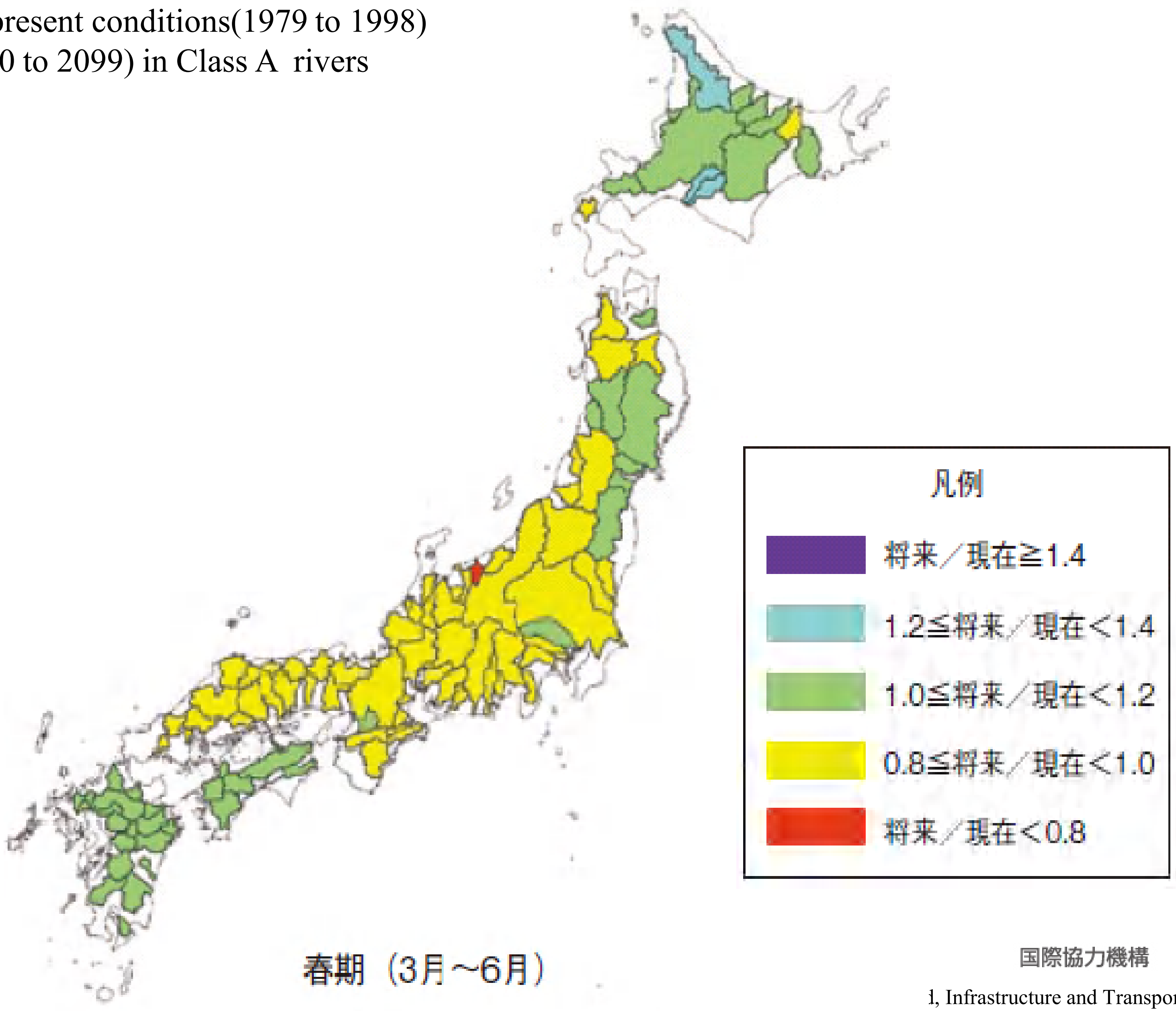


※　Circled number is number of calculated river system

More frequent and serious droughts　渇水

After 100 years, rainfall decrease in March - June

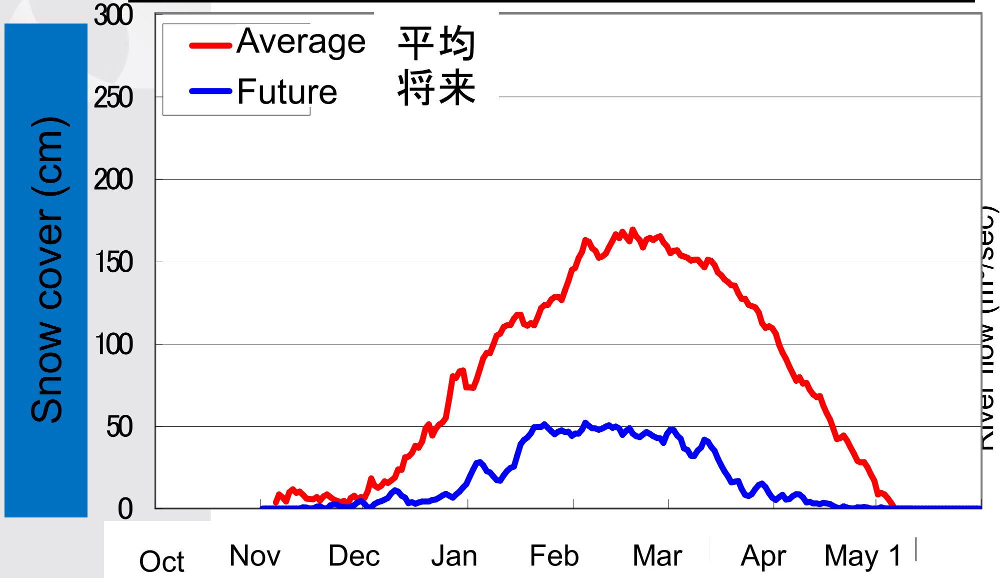
Comparison between present conditions(1979 to 1998) and future rainfall(2080 to 2099) in Class A rivers



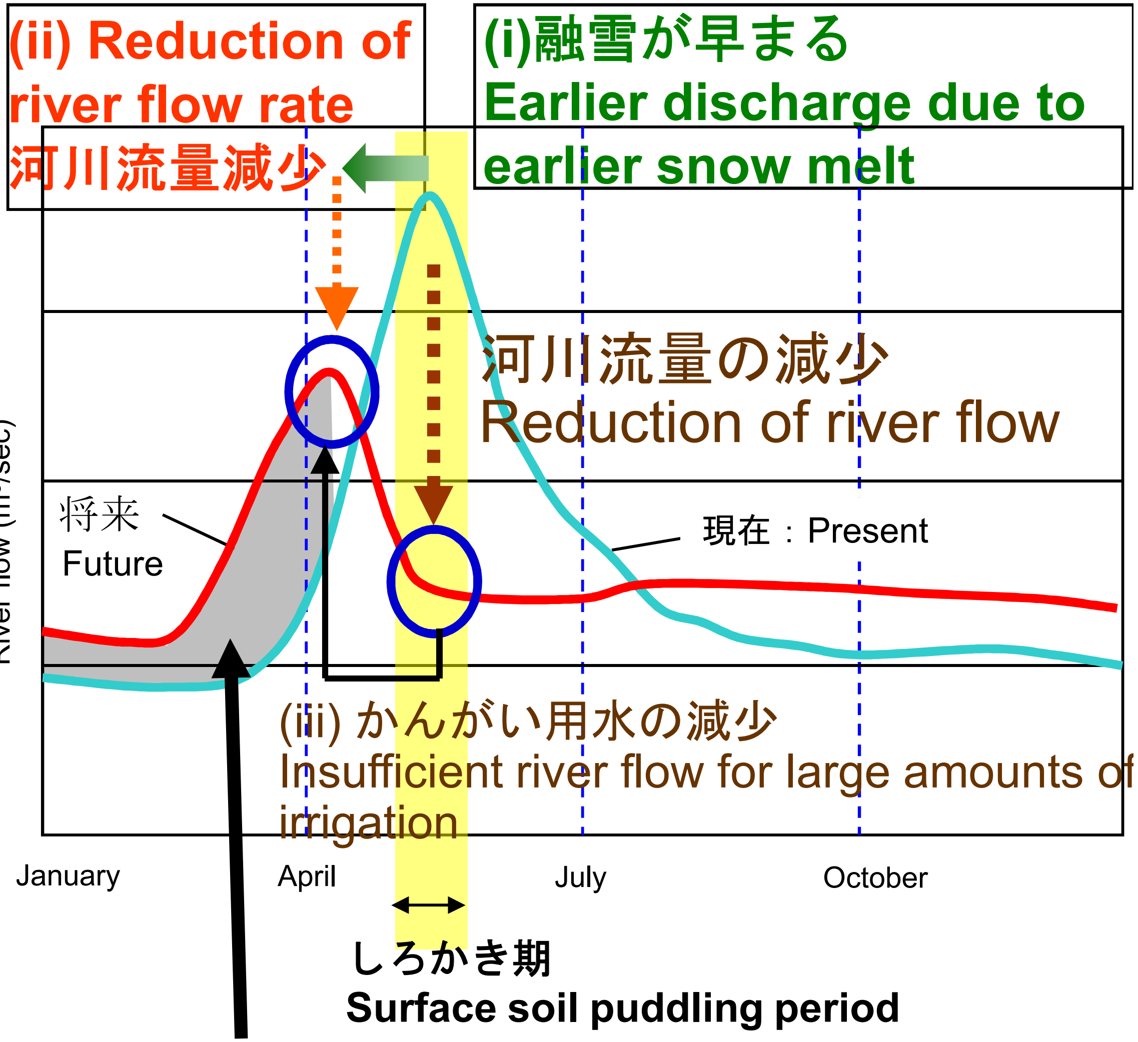
l, Infrastructure and Transport

More frequent and serious droughts
Snow fall pattern will change　降雪時期の変化

積雪の減少100年後Change in snow cover in 100 years (藤原Fujiwara)



*Prepared by Ministry of Land, Infrastructure and Transport based on Regional Climatic Model (RCM) 20, a global warming prediction model, developed by Japan Meteorological Agency.



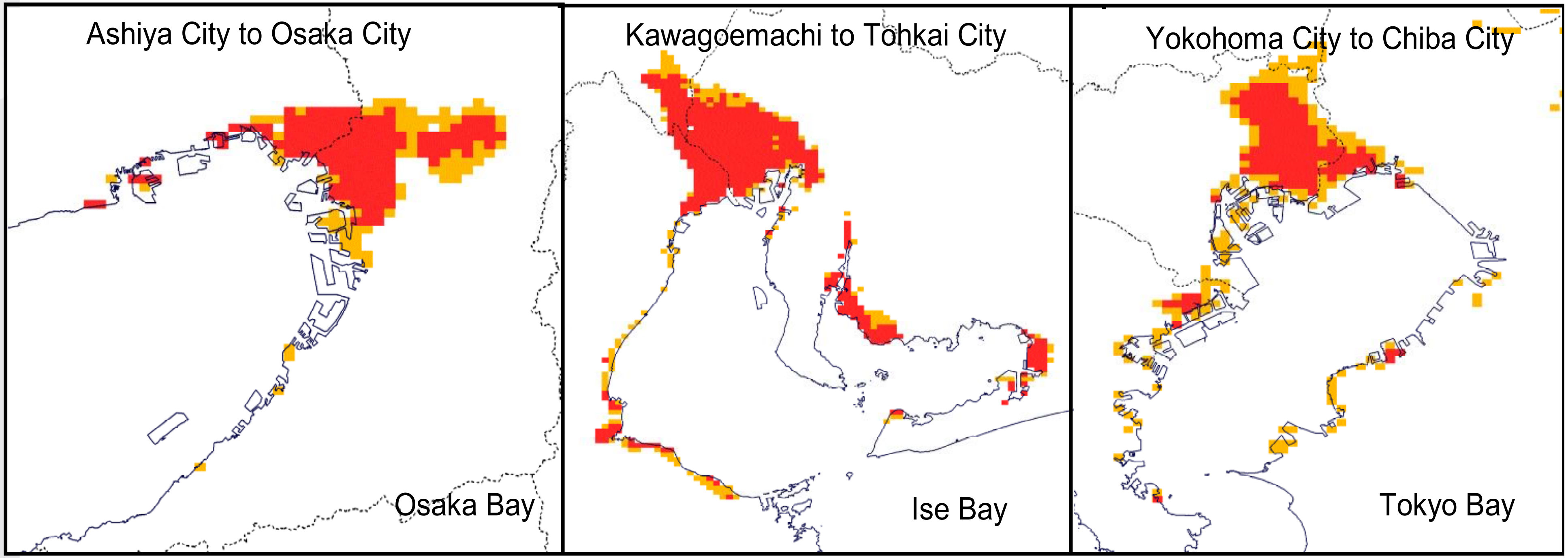
ダムでは対応が困難
Release of reservoir water not contributing to effective water use
Where the reservoir is full, released water is not used effectively.

Source: Water Resources in Japan 2007, Ministry of Land, Infrastructure and Transport

Increase of areas below sea level, and of inundation risks　沿岸災害リスク

Increases of below-sea-level areas in three large metropolitan areas (Tokyo-Yokohama, Nagoya, and Osaka-Kobe)

Increasing areas with flood risks



	現状	海面上昇後	倍率
面積（km²）	577	879	1.5
人口（万人）	4.04	5.93	1.5

*Prepared by the River Bureau based on the national land-use digital information.
*Shown are the areas at elevations lower than sea level shown in a three-dimensional mesh (1 km x 1 km). Total area and population are based on three-dimensional data.
*No areas of surfaces of rivers or lakes are included.
*A premium of 60% is applied to the potential flood risk area and to the population vulnerable to flood risk in the case with a one-meter rise of sea level.

Recommendations

沿岸や低地では
in coastal and low-lying areas:

-豪雨と巨大台風の頻発　More frequent heavy rains and more intense typhoons

⇒ 水害の増加　Frequent and serious flood and sediment disasters

-海面上昇と台風　Sea level rise and more intense typhoons

⇒ 高潮、沿岸災害　Frequent and serious high tides and coastal erosions

-降雨と河川流量の変化　Wider range of variation of rainfall intensity and change of river flow

⇒ 渇水　Frequent and serious droughts

Recommendation Basic policy

1. 「犠牲者ゼロ」　Adaptation measures to achieve "zero casualty"
   「これまでは被害ゼロ」　Paradigm shift from "Zero damage"

2. 国家機能の麻痺を回避：　Keeping national functions
   首都圏など中枢機能
   In strategic centers, such as the Tokyo Metropolitan area,

Basic concept for managing increasing risks
- Multiple measures in flood management -