United Nations Educational, Scientific and Cultural Organization
International Centre for Water Hazard and Risk Management under the auspices of UNESCO
Public Works Research Institute, National Research and Development Agency, Japan

Formulation of adaptation measures for flood management under the uncertainty of future projection

January 24th 2019

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The Fifth Assessment Report of IPCC

"Extreme precipitation events will become more intense and frequent in many regions and cause concerns for the possibility of further intensification of flood disasters in the future"

The Synthesis Report of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)

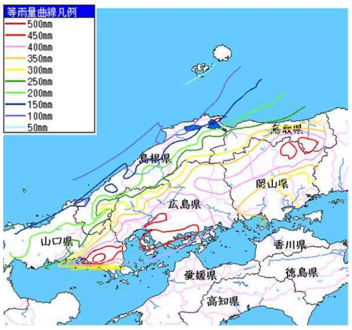
↓

Future changes in discharge, inundation, and other aspects of a flood hazard should be analyzed for the formulation of adaptation measures

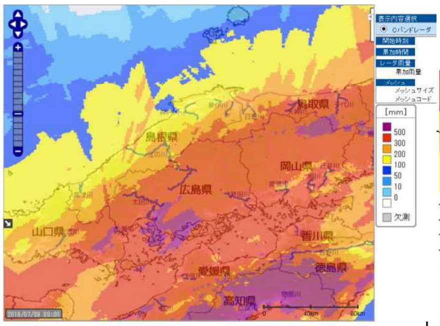
West Japan Flood in July 2018

- From July 5, 2018, seasonal rain (Bai-u) front started active.
- Nimi city and Kurashiki city were recorded the heaviest rainfall in recorded history.
- Highest water levels were recorded at 13 observatories in 9 rivers in recorded history, such as Takahashi river in Okayama Pref. and Ashida river in Hiroshima Pref.

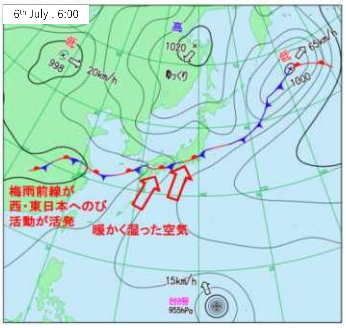
■ Same amount of rainfall (#1)



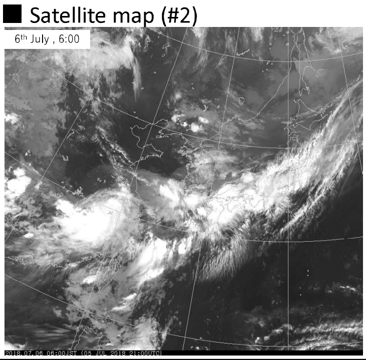
■ Total amount of rainfall (#1)



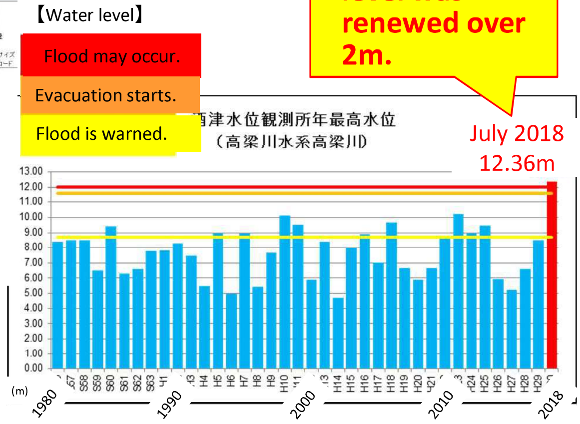
■ Weather map (#2)



■ Satellite map (#2)



Highest water level was renewed over 2m.



Sakazu observatory, Takahashi river

#1: Ministry of Land, Infrastructure, Transport and Tourism, Japan
#2: Japan Meteorological Agency Home Page

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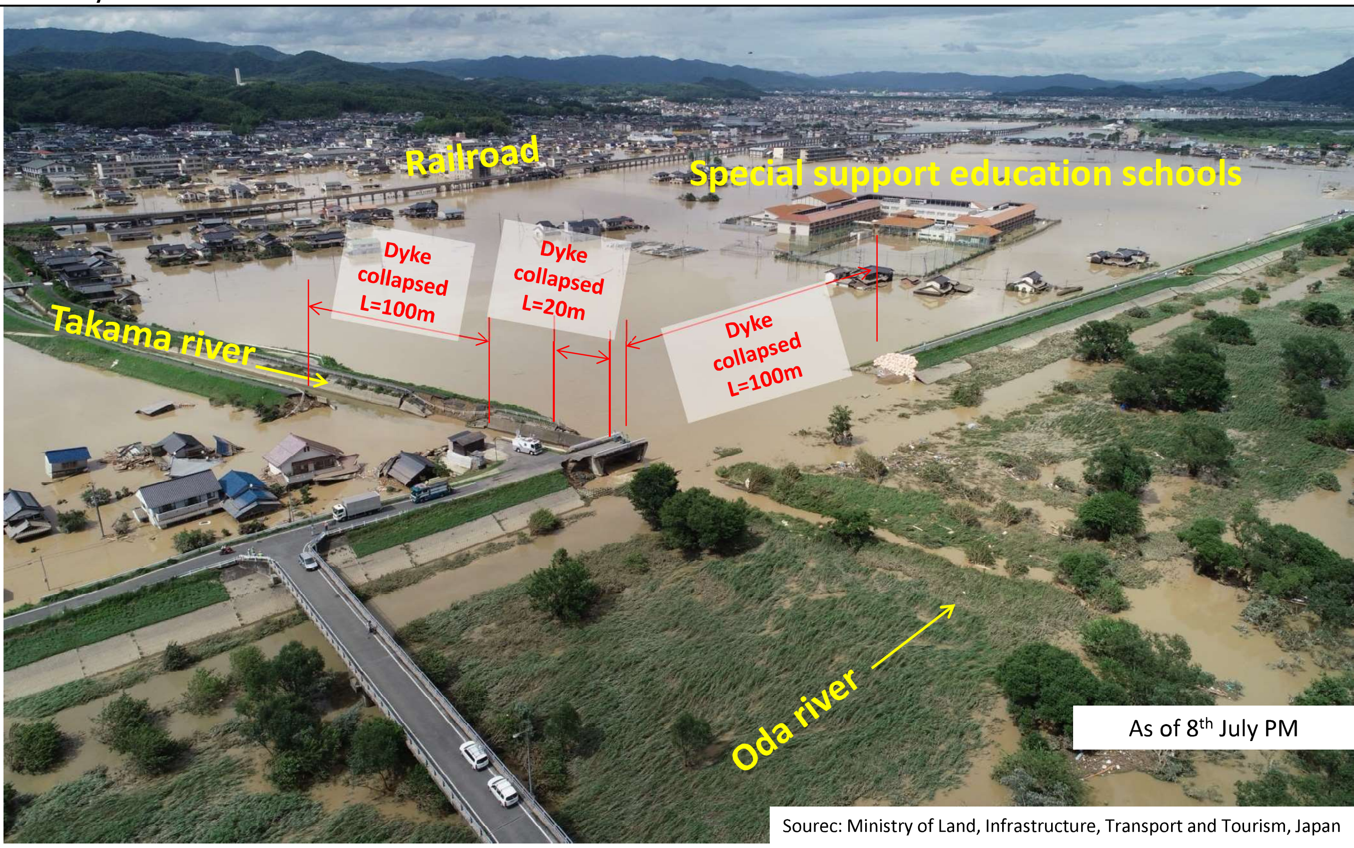
West Japan Flood in July 2018

- Dykes on the Oda river and one of its branch Takama river were collapsed at Mabi town.
- Many houses or businesses area were inundated.



As of 8th July PM

Sourec: Ministry of Land, Infrastructure, Transport and Tourism, Japan

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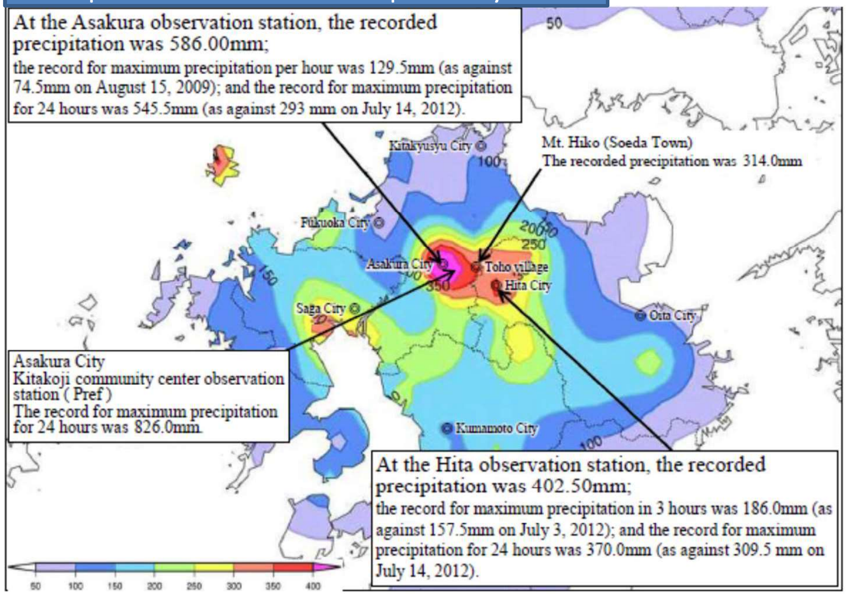
North Kyushu Flood in July 2017

- On July 5, 2017, there was heavy rainfall from noon till night in the North Kyushu area.
- Radar measured precipitation at around 1,000mm in 24hrs for Asakura city in Fukuoka Pref. and 600mm for Hita city in Oita Pref.

Precipitation distribution map for July 5 to 6



(Source : Compiled from the published data of the Japanese Meteorological Agency)

- Human loss : 42 deaths and persons missing; 13 seriously injured; and 9 less seriously injured.
- Housing damage : 335 units completely destroyed; 1,091 half destroyed; 172 suffering substantial above the floor; and 1,441 less substantial immersion

(As of 1st June, 2018)

Identification of Uncertainty

There is uncertainty in the prediction of future condition for formulating adaptation measures

- **Uncertainty caused by future climate scenarios (RCP2.6, RCP4.5, RCP6.0, RCP8.5)**
- **Uncertainty caused by different Global Climate Models (GCMs)**

Assessment of Uncertainty

Evaluation of uncertainty caused by different GCMs

"Climate Change and Flood Hazard Simulations Tools for ADB Spatial Application Facility (Final Report 2018.06)"

- **Select models from Coupled Model Intercomparison Project (CMIP)5 that meet basic requirement of meteorological data** (monthly precipitation, outgoing long-wave radiation, pressure at sea level, air temperature 850h Pa level, zonal wind 850h Pa level, meridional wind 850h Pa level)
- **Identify suitable model by comparing simulated and observed data in terms of the spatial correlation coefficient (CC) and the absolute values of root mean square error (RMSE) of meteorological elements**
- **Statistic downscaling is undertaken to the suitable models to compare the precipitation condition**

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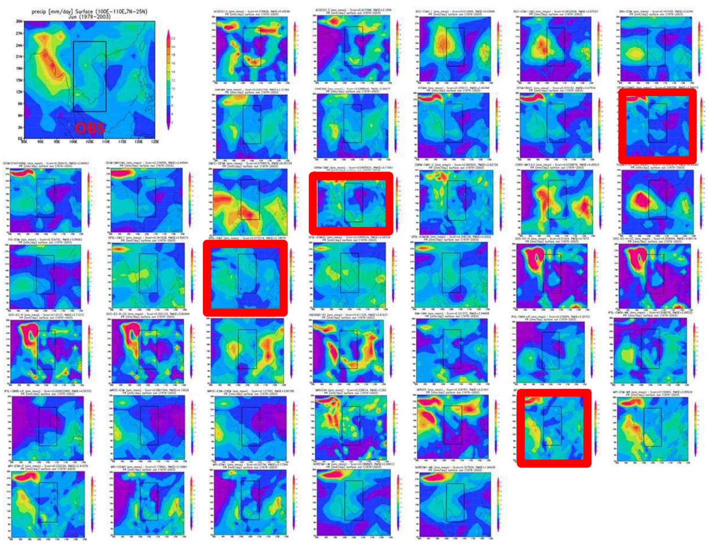
Differences among GCMs

- **Though the uncertainty caused by model differences in predicting the impact of climate change at a global scale has been decreasing as GCMs have been improved year by year, the uncertainty generated in prediction at a regional scale is still significant.**

OBS (observed)		ACCESS1.0	ACCESS1.3	BCC-CSM1.1	BCC-CSM1.1 (m)	BNU-ESM
		CanCM4	CanESM2	CCSM4	CESM1 (BGC)	CESM1 (CAM5)
CESM1(FASTCHEM)	CESM1 (WACCM)	CMCC-CMS	CNRM-CM5	CNRM-CM5-2	CSIRO-Mk3.6.0	FGOALS-g2
FIO-ESM	GFDL-CM2.1	GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-H	GISS-E2-H-CC
GISS-E2-R	GISS-E2-R-CC	HadCM3	HadGEM2-ES	INM-CM4	IPSL-CM5A-LR	IPSL-CM5A-MR
IPSL-CM5B-LR	MIROC-ESM	MIROC-ESM-CHEM	MIROC4h	MIROC5	MPI-ESM-LR	MPI-ESM-MR
MPI-ESM-P	MRI-CGCM3	MRI-ESM1	NorESM1-M	NorESM1-ME		



Comparison of GCMs and select suitable models for statistic downscaling (South East Asia)

"Climate Change and Flood Hazard Simulations Tools for ADB Spatial Application Facility" (Final Report 2018.06)

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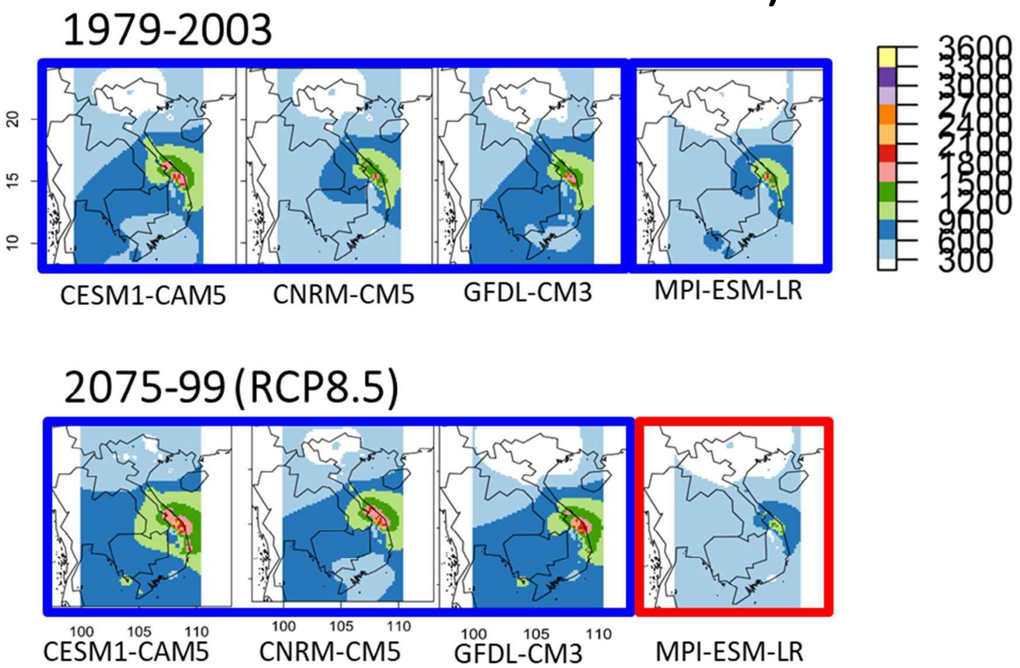
Differences among GCMs

- **Comparison of the selected suitable models (statistic downscaling at Vietnam area)**

(Average Rainfall in October-November-December)



"Climate Change and Flood Hazard Simulations Tools for ADB Spatial Application Facility" (Final Report 2018.06)

Assessment of Climate Change Impacts

Combined method for the assessment of climate change impacts

1. **Quantitative impact assessment applied to the formulation of adaptation measures (Resolution is high enough for planning)**

2. **Qualitative impact assessment for the evaluation and understanding of uncertainty**

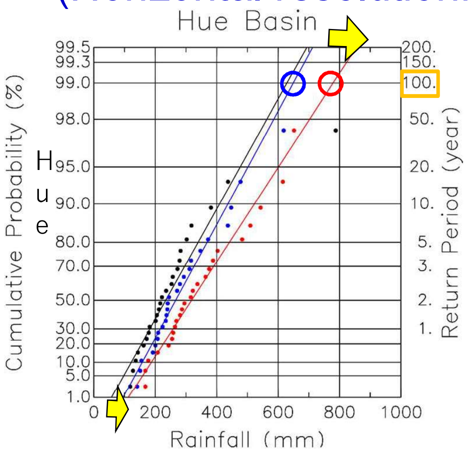
Assessment of Climate Change Impacts

Quantitative impact assessment applied to the formulation of adaptation measures

- **The Atmospheric Global Climate Model (AGCM) is used for the calculation of atmospheric conditions with the sea surface temperature (SST) as premises.**
- **The model provides a good resolution since a load of calculation is relatively low compared to coupled GCMs, and its grid size of calculation is smaller than other models.**
- **Quantification of uncertainty derived from the difference of scenarios is conducted**

Quantitative Impact Assessment

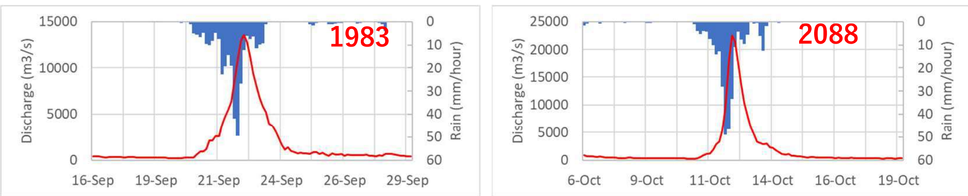
- Dynamic Downscaling at Hua, Vietnam using MRI-AGCM3.2S
  (Horizontal resolution: 6 km)



Black line: Observed
Blue line: Present
Red line: Future

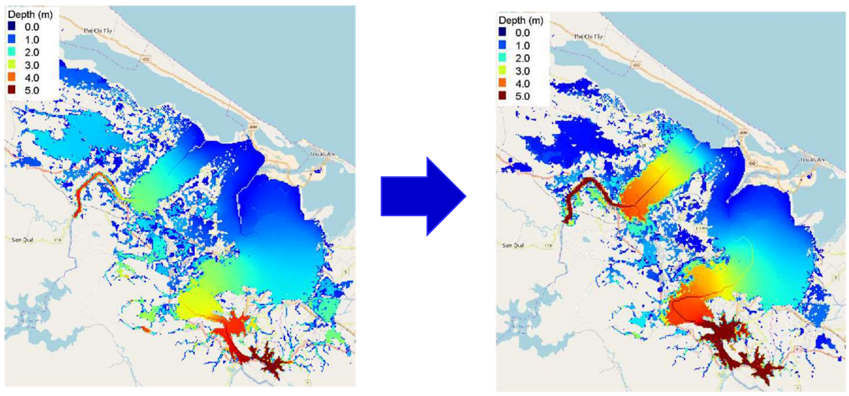
It is very likely that the heavy rainfall in the Hue area will increase across the wide range of return periods.

Rainfall Patters (1/100) and Flood Discharge



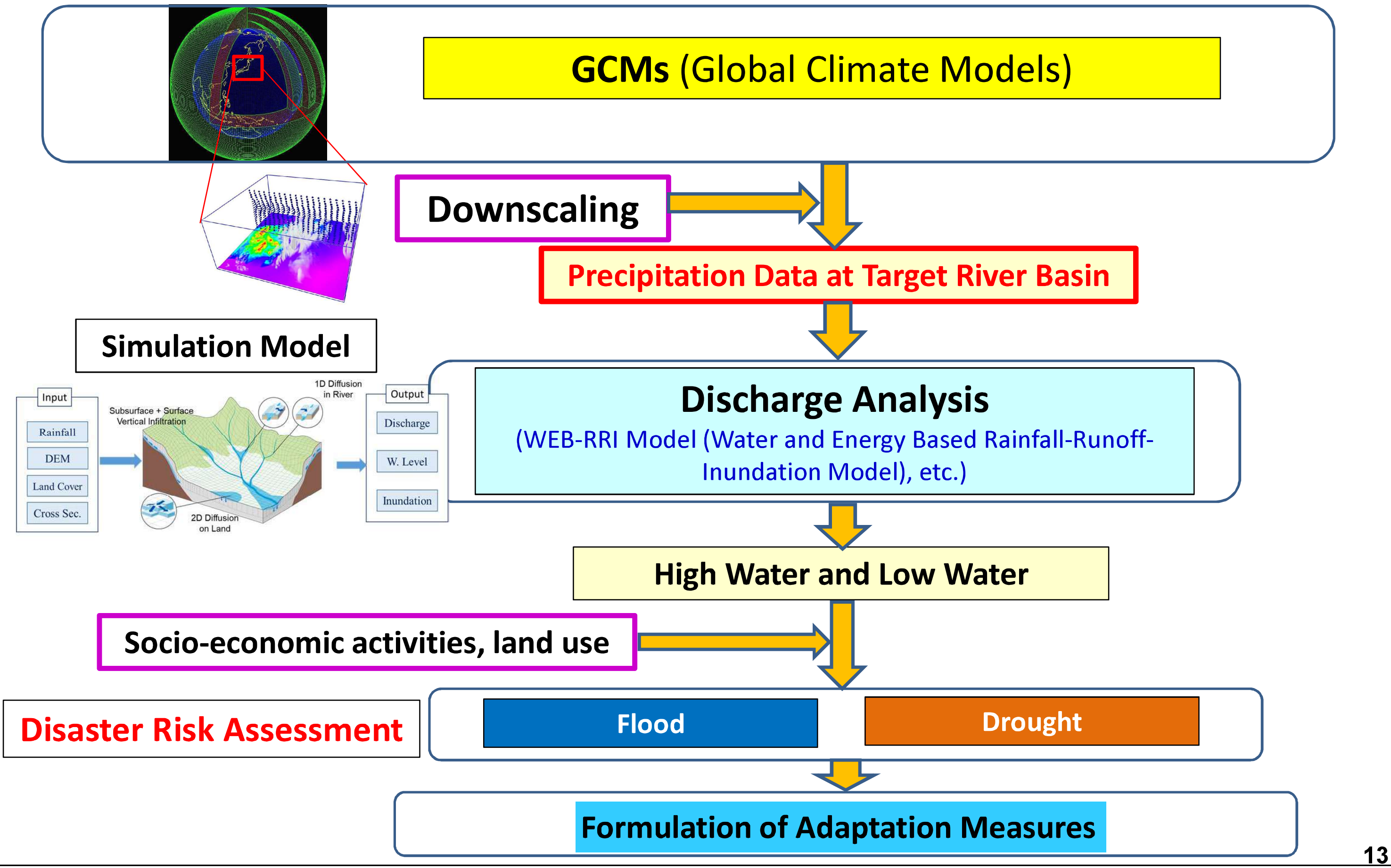
Present

Future (RCP8.5 2075-2099)



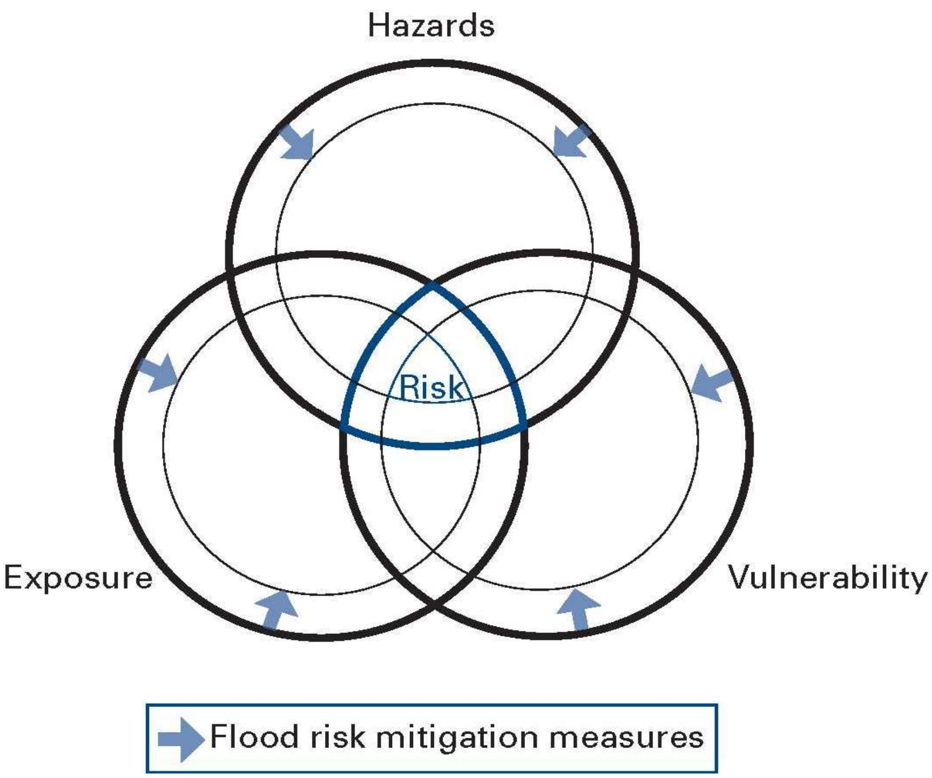
“Climate Change and Flood Hazard Simulations Tools for ADB Spatial Application Facility” (Final Report 2018.06)

Formulation of Adaptation Measures



Constructs of Disaster Risk and Its Reduction

Disaster Risk = f (Hazard, Exposure, Vulnerability)



(Social Aspects and Stakeholder Involvement in IFM, WMO 2006)

Disaster Risk Assessment

- **Data & Information**
  - hydro-meteorological data, DEM, river cross section, etc.

Hydro-meteorological analysis

- **Water-related hazard**
  - affected area, intensity, duration, etc.

Risk Assessment by Risk Indicators (Damage Curve)

- **Socio-economic damage**
  - casualties, economic value of damage, damage ratio, socio-economic influence, etc.

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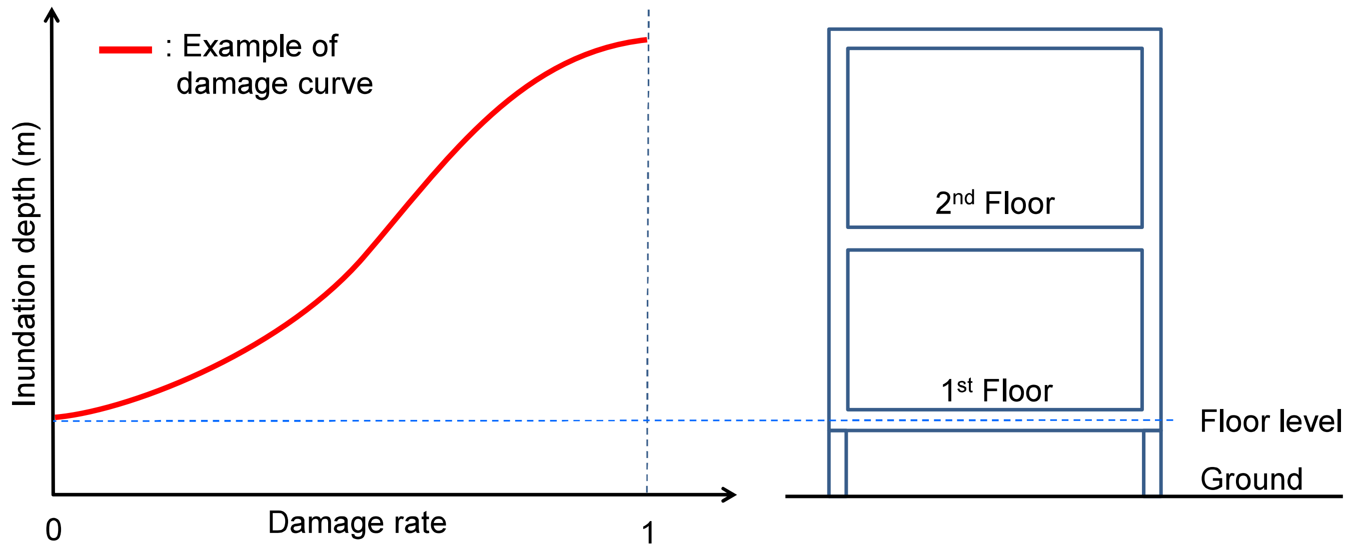
Disaster Risk Assessment (Damage Curve)

Damage curve shows a relation of hazard and damage rate



(Damage curve of building for inundation)

Damages = Exposure (people, housing etc.) × damage rate

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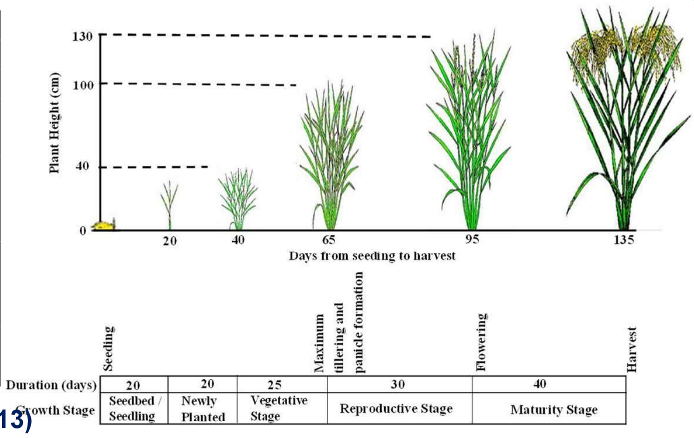
Disaster Risk Assessment (Rice-Crops)

Growth Stage of Rice	Calculation Method
Seedbed / Seedling 20 days from palay germination	***Value of production losses*** = Area affected x Cost of input / hectare x yield loss
Newly Planted Stage 1-20 days after sowing	
Vegetative Stage (21-45 days)	
Reproductive Stage (46-75 days)	***Value of Production Losses*** = Volume of losses x most recent farm gate price ***Volume of losses*** = Most recent yield/hectare x area damaged x Yield loss
Maturing Stage (76-115 days)	

Flood damage matrix: Rice-crops Damage

Growth stage	Days of submerge			
	1-2	3-4	5-6	7
	Estimated yield loss (%)			
Vegetative stage: Minimum Tillering /Maximum Tillering	10-20	20-30	30-50	50-100
Reproductive Stage: Panicle Initiation/Booting Stage (Partially Inundated)	10-20	30-50	40-85	50-100
Reproductive Stage: Panicle Initiation/Booting Stage (Completely Inundated)	15-30	40-70	40-85	50-100
Maturity Stage: Flowering stage	15-30	40-70	50-90	60-100
Ripening Stage	5	10-20	15-30	15-30

Days and plant height of rice crops at its each stage



Source: Bureau of Agricultural Statistics, Philippines (2013)

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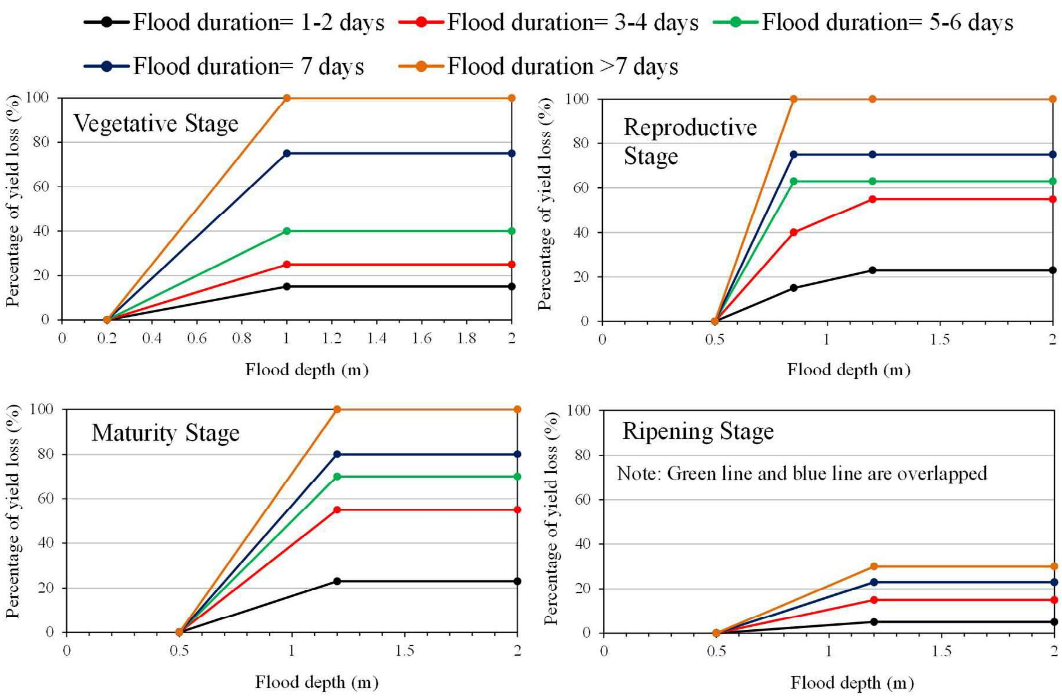
Disaster Risk Assessment (Rice-Crops)

Damage Curve

The damage curve considers growth stage, flood depth, and flood duration.



Reference: *Shrestha, B. B., Okazumi, T., Mamoru, M. and Sawano, H.: Flood damage assessment in the Pampanga river basin of the Philippines, Journal of Flood Risk Management, Vol. 9, No. 4, pp.355-369, 2016. DOI: 10.1111/jfr3.12174*

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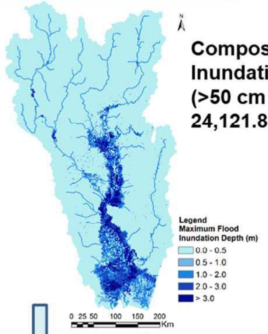
Disaster Risk Assessment (Rice-Crops)

Comparison of Present and Future Disaster Risk (Chao Phraya River Basin, Thailand)

100-Year Flood

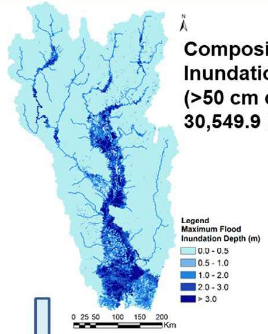
Present Climate | **Future Climate (RCP 8.5)**

[Flood Hazard]



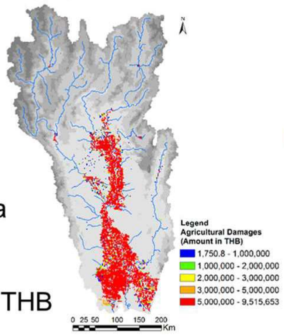
Composite of Inundation Area (>50 cm depth)= 24,121.8 km^2

Inundation area increased by 27 %



Composite of Inundation Area (>50 cm depth)= 30,549.9 km^2

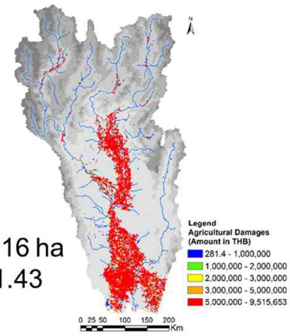
[Flood Damage]



Damage area =1,748,304 ha
Estimated Damage =44.48 billion THB (Thai Baht)

Damage area increased by 13 %

Damage value increased by 16 %



Damage area=1,979,316 ha
Estimated Damage=51.43 billion THB

Flood Disaster Risk Reduction Strategy

Identify disaster risk reduction measures for target hazard

- **Reduce Hazard** (Dam, Diversion channel, etc.)
- **Reduce Exposure** (River improvement, Land use, etc.)
- **Reduce Vulnerability** (Building code, Early warning system, Emergency action, etc.)

Formulate Flood Disaster Risk Reduction Strategies

- Preventive investment (Structural measures)
- Land use planning
- Contingency planning

Challenges of Adaptation Measures

Uncertainty and remaining risk should be noted in formulating adaptation measures for climate change

- ➢ **Uncertainty of future prediction derived from the difference among models and scenarios**
- ➢ **Remaining Risk (possibility of a flood occurrence exceeding the probability (return period) of a target flood set to design structural measures)**

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Formulation of Contingency Plan

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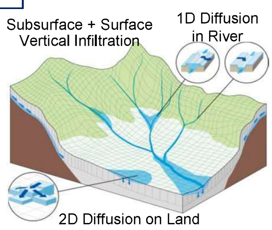
Flood Contingency Planning (Calumpit, the Philippines)

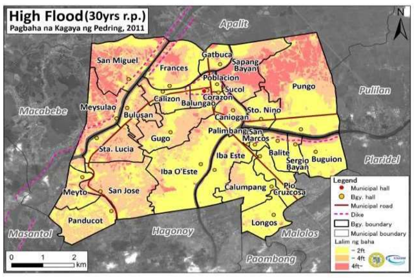
Assume disaster scenario

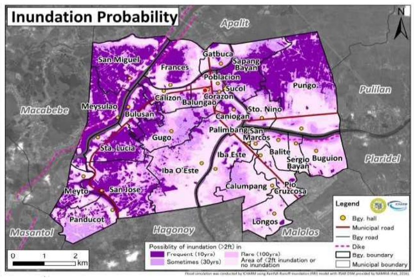
Step 1: Understanding current conditions

Step 2: Risk identification



Flood Simulation
by using RRI Model and IfSAR DEM (5m grid)





Inundation (30yrs return period) and inundation probability map

Step 3: Impact analysis

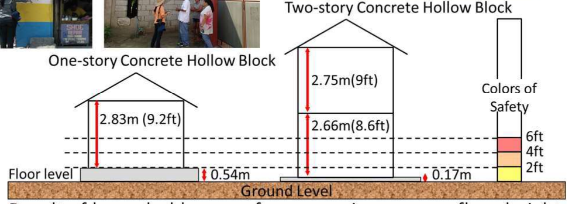
Color classification is same as "Colors of Safety"

Lead time before inundation and duration of inundation can be checked using water chart

Understand what will happen

Time-series inundation chart showing lead time and duration of inundation

Colors of Safety	Flood Case	<Legend>		< 2ft (<0.3048m)		< 4ft (<1.2192 m)		> 4ft (>1.2192m)				Inundation depth (m)													
		Day1		Day2		Day3		Day4		Day5		Day6		Day7		Day8		Day9		Day10		Day11		Day12	
Purok 1	Ordinary flood (10yrs return period)	0.00	0.00	0.00	0.00	0.00	0.71	0.90	0.98	1.00	0.93	0.85	0.74	0.35	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	High flood (30yrs return period)	0.00	0.00	0.00	0.00	0.00	0.84	1.02	1.16	1.21	1.21	1.20	1.17	1.14	1.08	0.96	0.81	0.69	0.58	0.47	0.00	0.22	0.00	0.00	0.00
	Extreme flood (100yrs return period)	0.00	0.00	0.00	0.00	0.44	0.93	1.22	1.38	1.43	1.47	1.50	1.51	1.50	1.45	1.42	1.34	1.25	1.12	1.05	1.00	0.92	0.83	0.75	0.63
	2011 Pedring and Quiel	0.00	0.00	0.00	0.00	0.00	0.83	1.01	1.15	1.20	1.20	1.19	1.16	1.13	1.12	1.15	1.16	1.17	1.13	1.10	1.05	0.99	0.87	0.67	0.46



Result of household survey for measuring average floor height

Step 4: Developing Coping Strategy ➡ **Step 5**: Developing Contingency Plan ➡ **Step 6**: Sharing and Updating Contingency Plan

Think how to prepare for flood

Community workshop discussing "What we do/improve" and "What we request"

Presentation by community representatives at workshop

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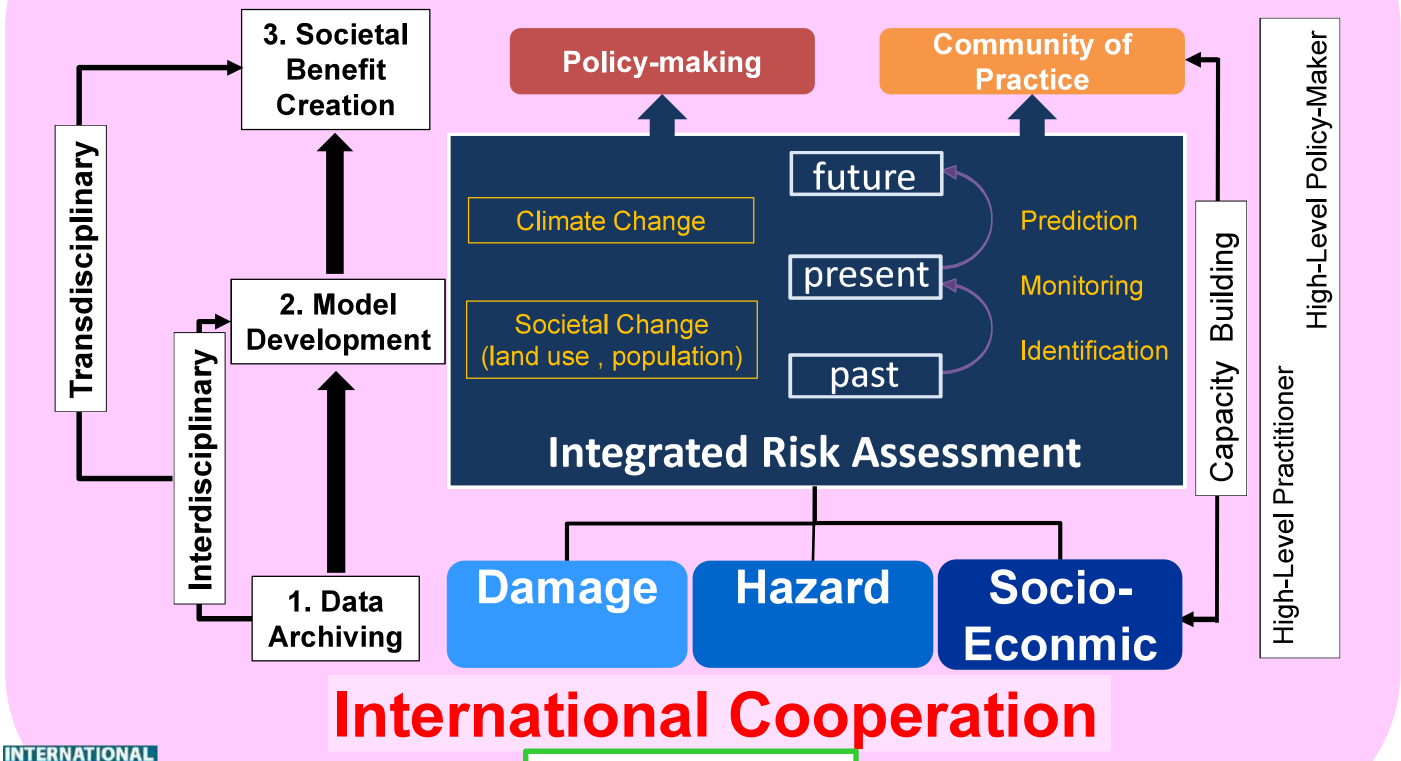
Platform on Water Resilience and Disasters



Platform on Water Resilience and Disasters

- **Philippines**
  - **Platform on Water Resilience and Disasters**
  - Activity: Meeting among related stakeholders in **Mar.** and **Jun.** 2017, **Mar.** and **May** 2018
  - Initial Target(s): Pampanga River & Davao River
- **Pakistan**
  - **Platform on Water Resilience and Disasters**
  - Activity: Meeting among related stakeholders in **Apr.** and **Dec.** 2017
  - Initial Target(s): Indus River
- **Myanmar**
  - **Platform on Water Resilience and Disasters**
  - Activity: Meeting among related stakeholders in **May** and **Nov.** 2017, **Sep.** 2018
  - Initial Target(s): Bago River & Sittaung River
- **Sri Lanka**
  - **Platform on Water Resilience and Disasters**
  - Activity: Meeting among related stakeholders in **Aug.** 2017 and **Mar.** 2018
  - Initial Target(s): Kalu River, Kelani River, Malvaththu River

Initial Target(s) → Demonstration activities using Data Integration and Analysis System (DIAS)


Thank you very much!
(http://www.icharm.pwri.go.jp)
PWRI and Mt. Tsukuba