伝統 革新 強靭性

UR Himeji+

UNDERSTANDING RISK GLOBAL FORUM 2024

TRADITION • INNOVATION • RESILIENCE

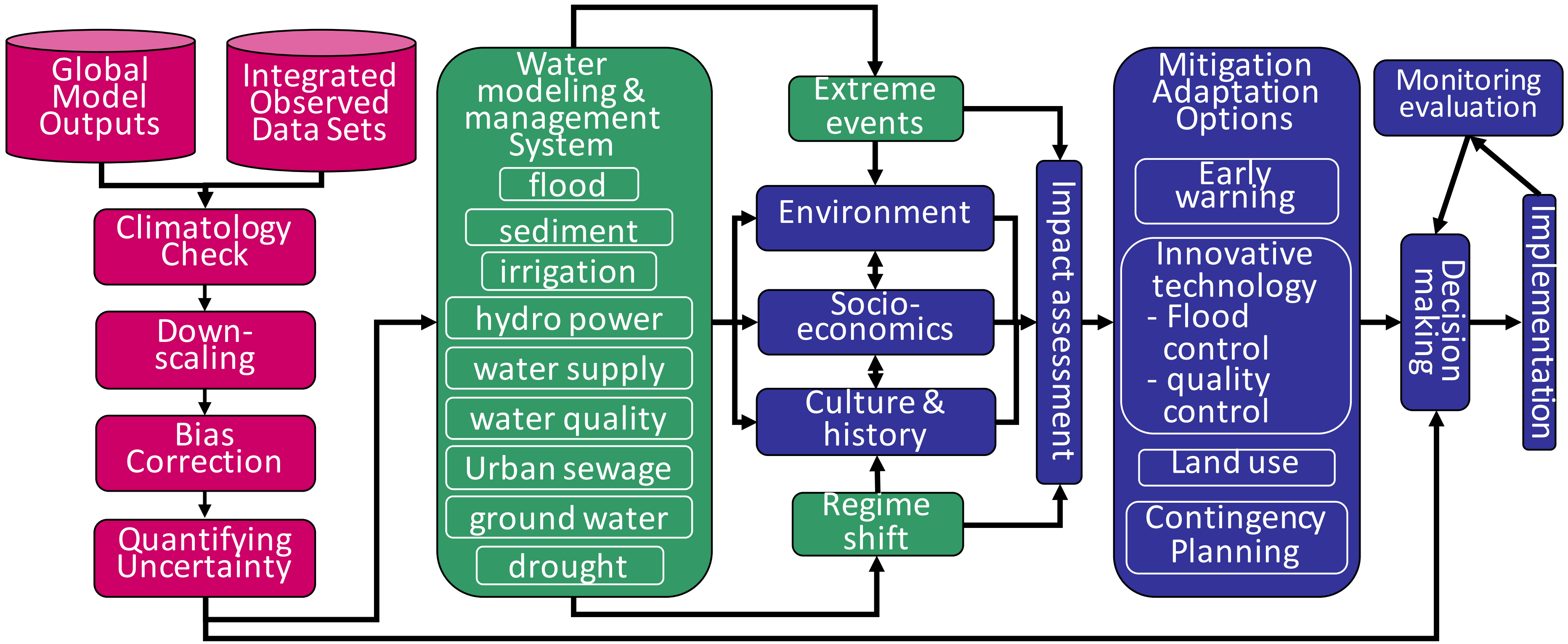
Bridging Science and Society:

The Key to Well-Informed DRR Decisions to Fight Climate Change

Speakers: Sameh, Kantoush
Menglu, Qin
Martin, Gomez-Garcia A.
Sanjeewa, Illangasingha

Moderator: Toshio, Koike

NIPPON KOEI


Global Model Outputs
Integrated Observed Data Sets
Climatology Check
Down-scaling
Bias Correction
Quantifying Uncertainty
Water modeling & management System
flood
sediment
irrigation
hydro power
water supply
water quality
Urban sewage
ground water
drought
Extreme events
Environment
Socio-economics
Culture & history
Regime shift
Impact assessment
Mitigation Adaptation Options
Early warning
Innovative technology
- Flood control
- quality control
Land use
Contingency Planning
Monitoring evaluation
Decision making
Implementation

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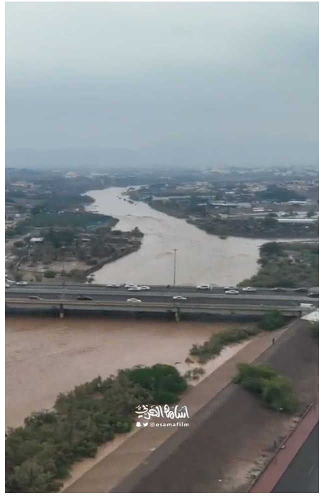
Hydro Hazards in Arid Environments Caused by Climate Extremes and Human Impacts

Professor: KANTOUSH Sameh

Water Resources Research Center
Disaster Prevention Research Institute
Kyoto University, JAPAN

Oman Muscat 2007

Jordan, Petra 2018



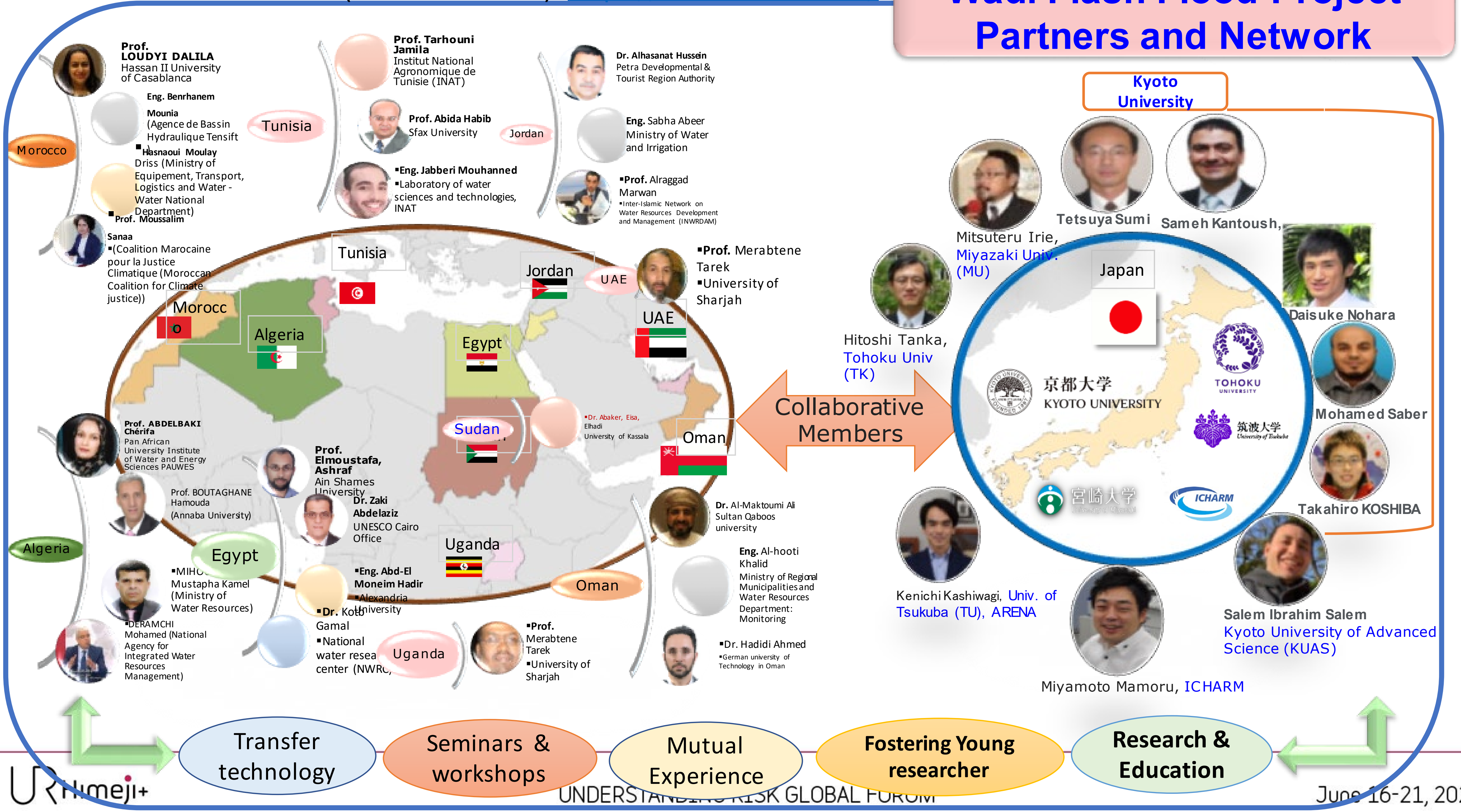
Saudi Arabia, Madinah 2023

UAE 2024 Dubai International Airport

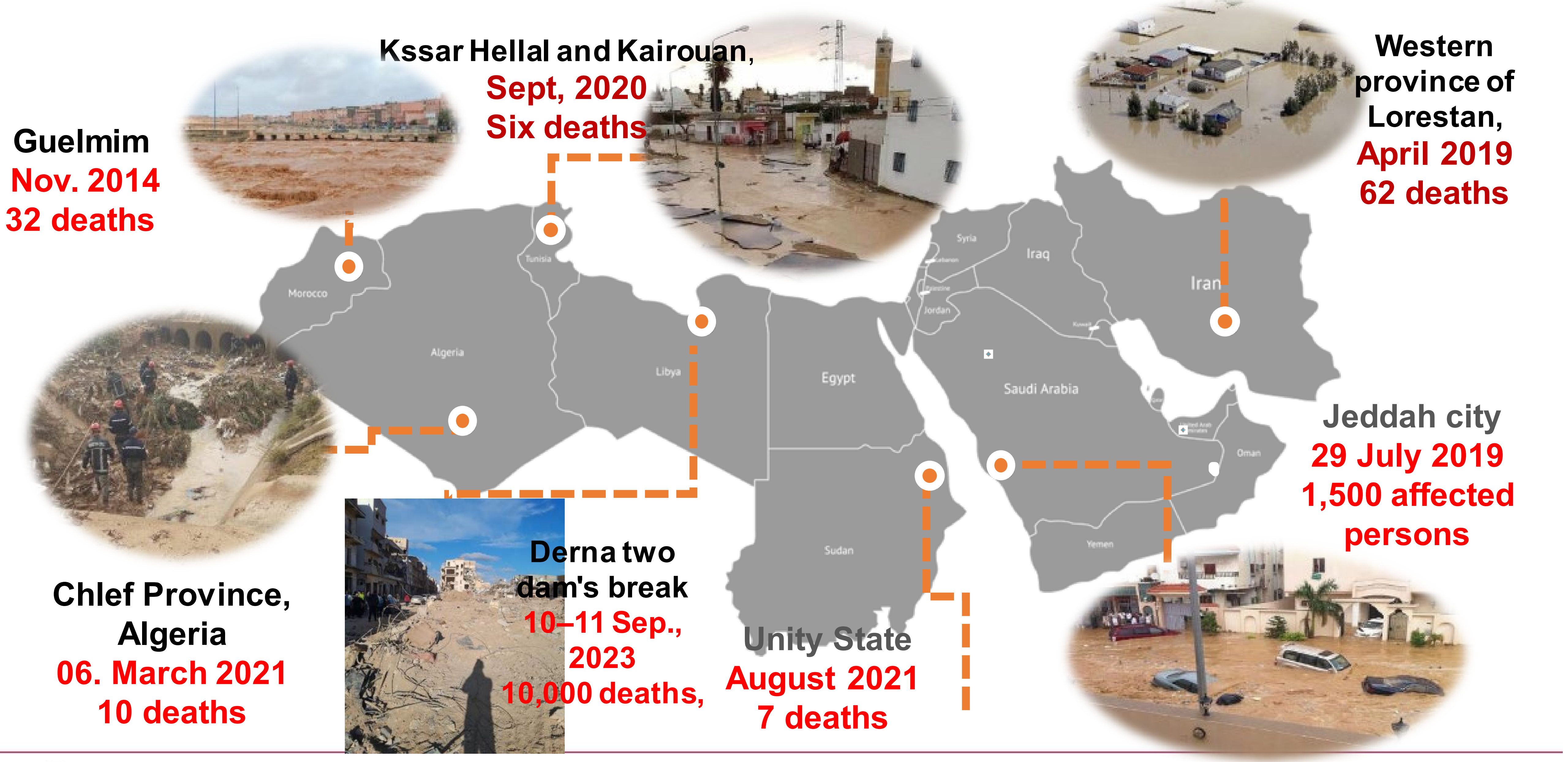
Libya: Wadi Derna Dam Failure 2023

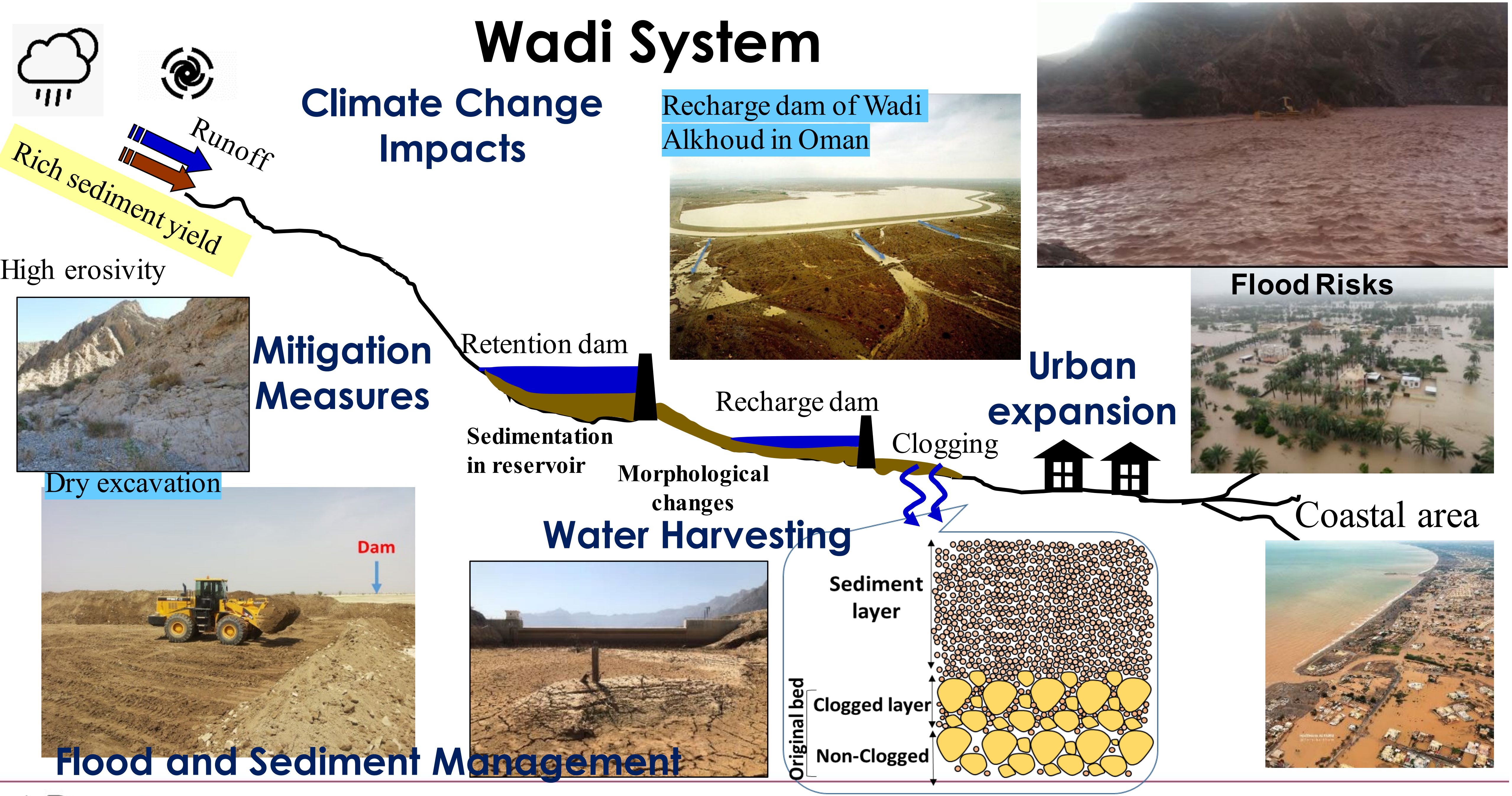
Wadi Flash Flood Network (MENA-WaFFNet) https://www.aaffnet.com/

Wadi Flash Flood Project Partners and Network



Extreme Flash Floods in the Middle East and North Africa (MENA)

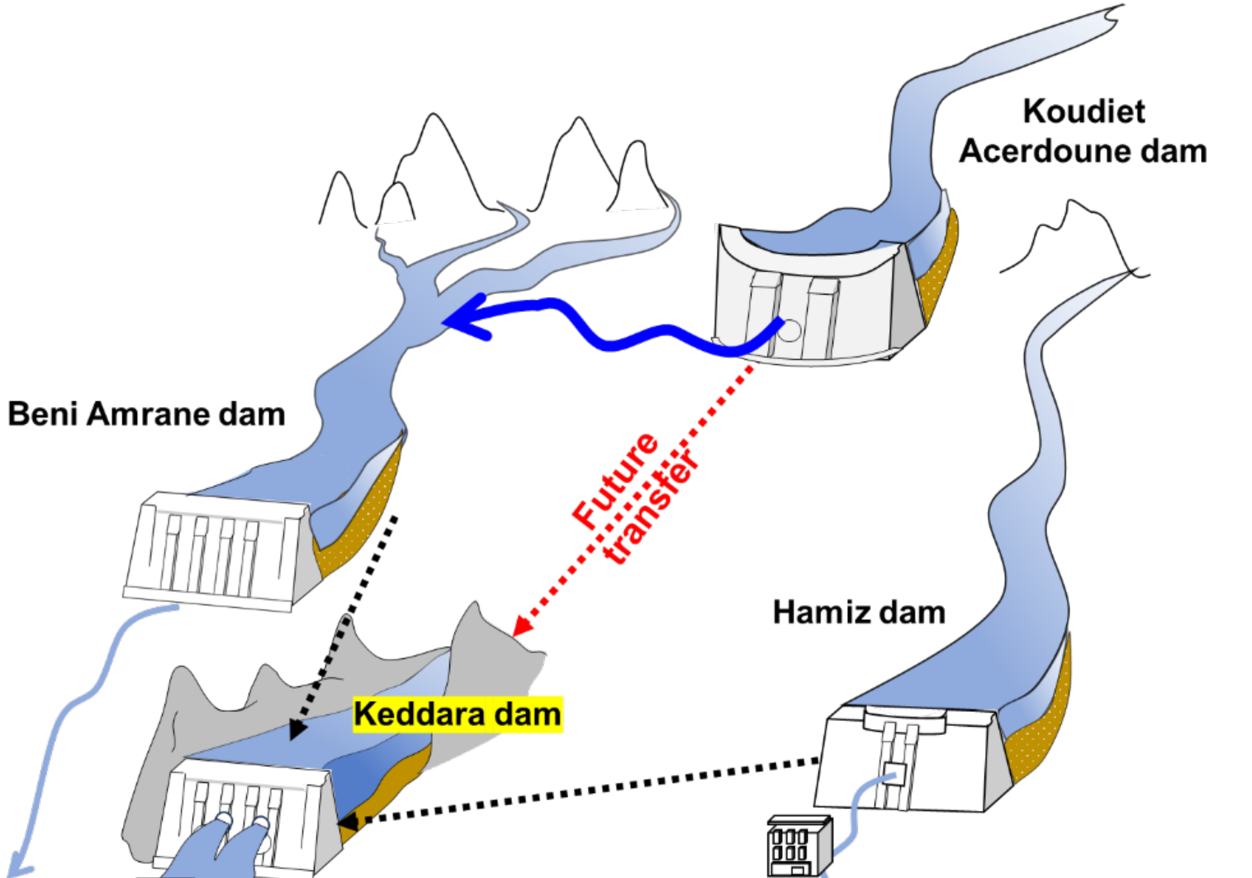




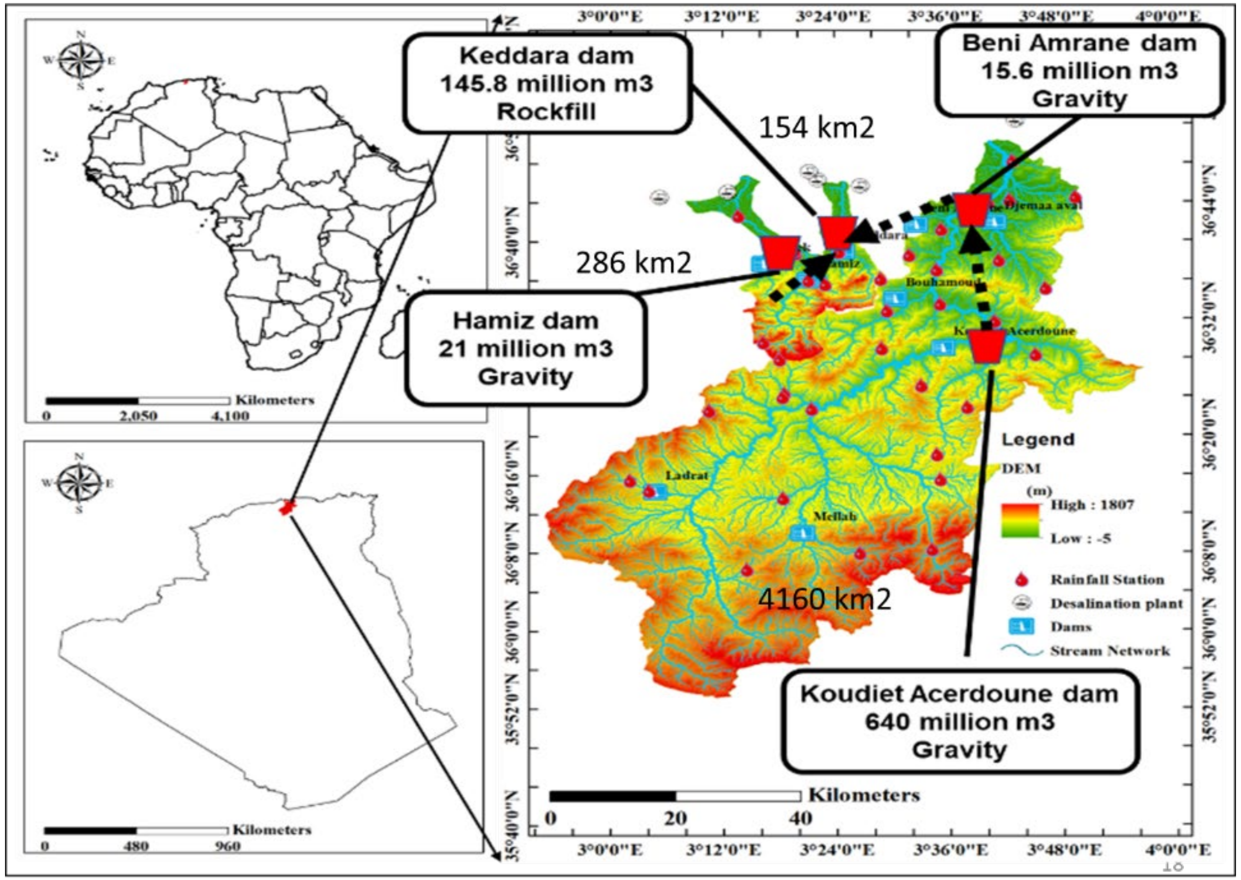
Wadi System
Climate Change Impacts
Runoff
Rich sediment yield
High erosivity
Recharge dam of Wadi Alkhoud in Oman
Flood Risks
Mitigation Measures
Retention dam
Sedimentation in reservoir
Recharge dam
Clogging
Morphological changes
Urban expansion
Coastal area
Dry excavation
Dam
Water Harvesting
Sediment layer
Original bed
Clogged layer
Non-Clogged
Flood and Sediment Management

Interbasin Water Transfers

Selected Target Region in Algeria

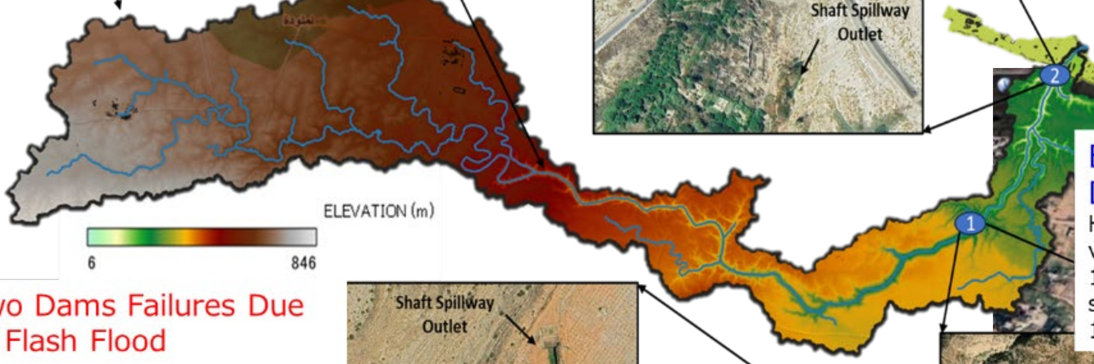


Missing coordination between stakeholders and other players hinders efficient management.



Wadi Derna Flood

70 km, 570 km²



Two Dams Failures Due to Flash Flood

Cause of collapse (currently being compiled by UNESCO, the Netherlands, the World Bank, Kyoto University, etc.)

1. Unexpected rainfall and inflow

(Flood spill capacity: 200-400m3/s, inflow of over 2000m3/s?)

2. Defects and weaknesses in the dam embankment

Abu Mansour Dam

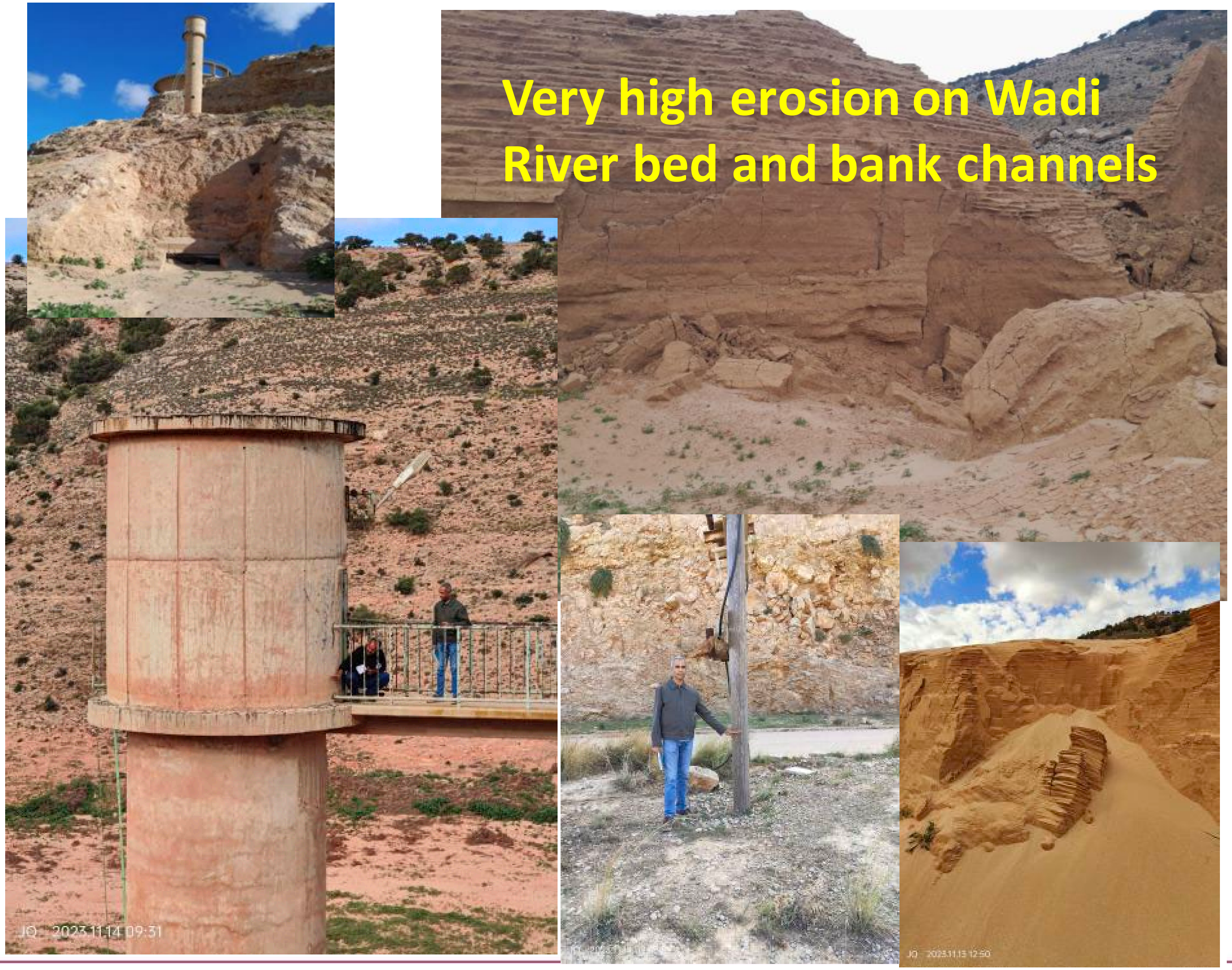
H=75m, dam volume 735,000m3, storage capacity 18 million m3, Designed in former Yugoslavia 1970s

El Bilad Dam

H=40m, dam volume 104,000m3, storage capacity 1.5 million m3

Abu Mansour dam（上流）

Two Dam Failure Wadi Derna Flood



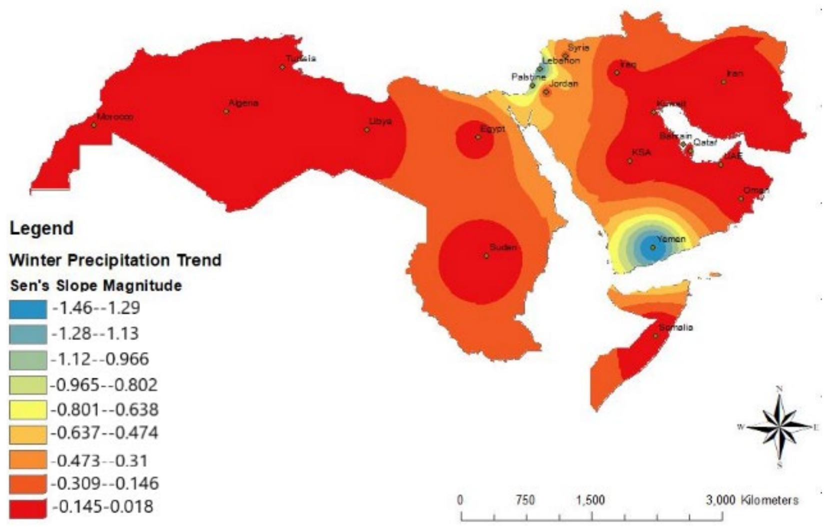
The 2nd deadliest dam failure in history, after the 1975 Banqiao Dam failure in China

جامع الصحابة
Assahaba Mosque

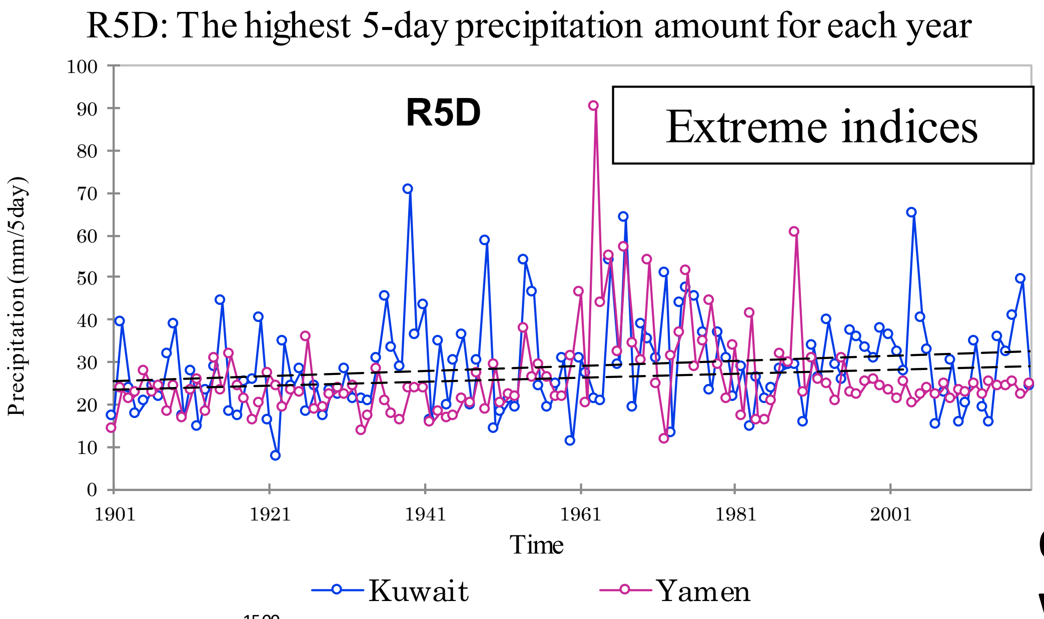
Flood Marker=3.85 m

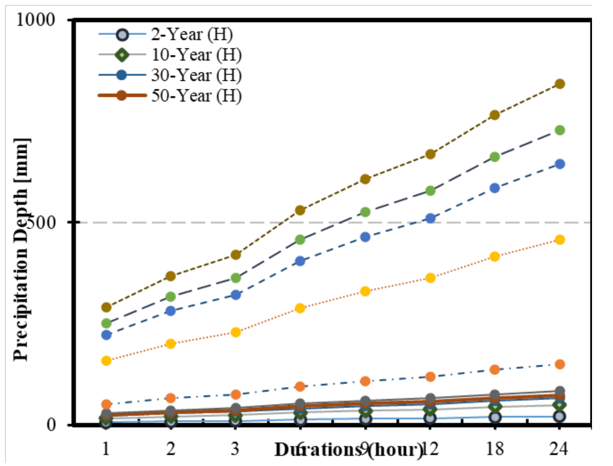
Described the flood disaster in Derna city

Current and Future Extreme over MENA Region

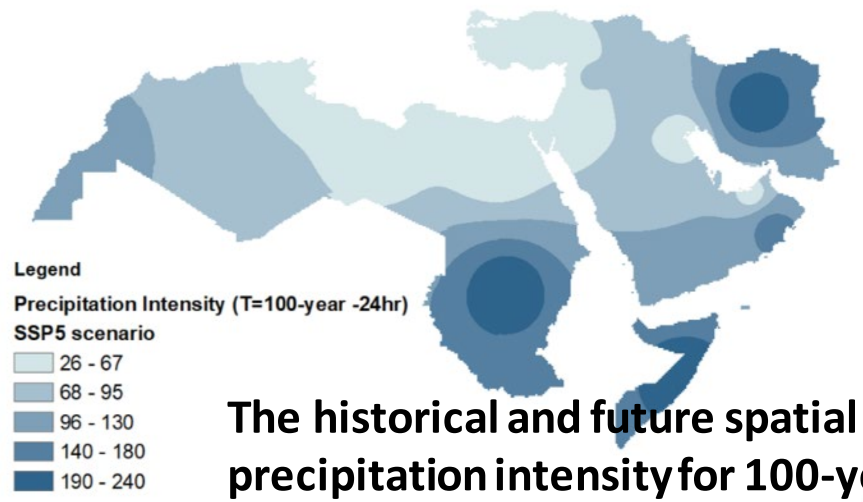


Annual and seasonal precipitation trend

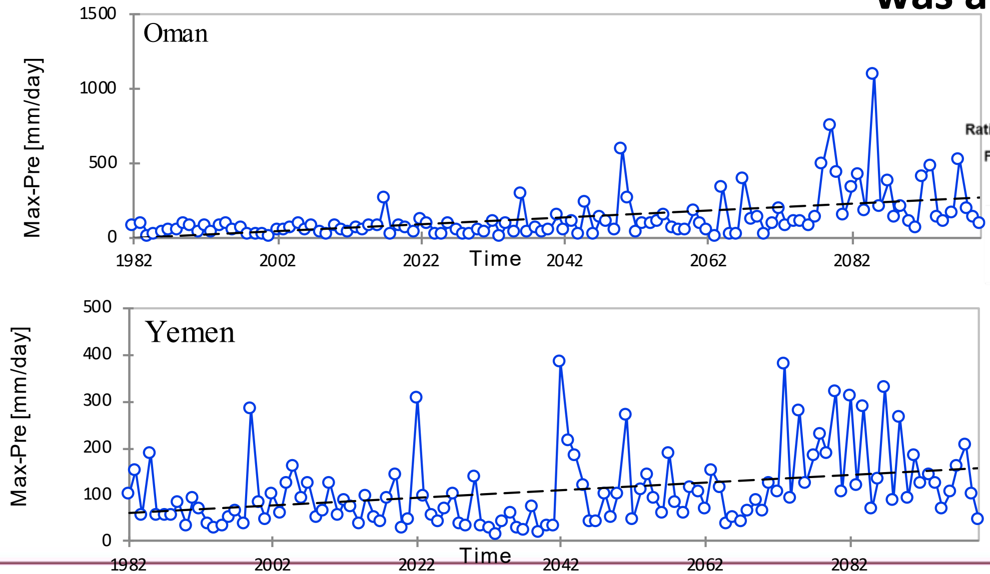


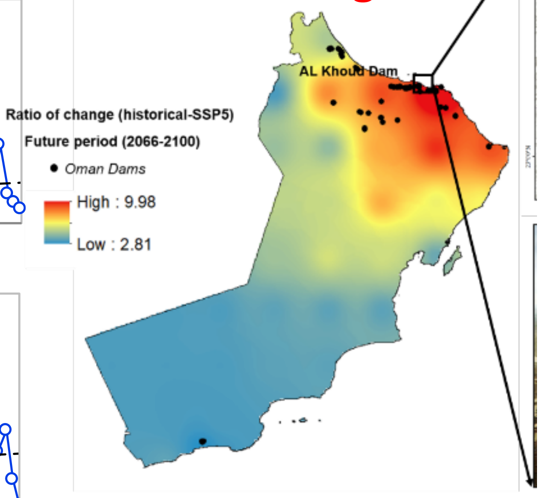


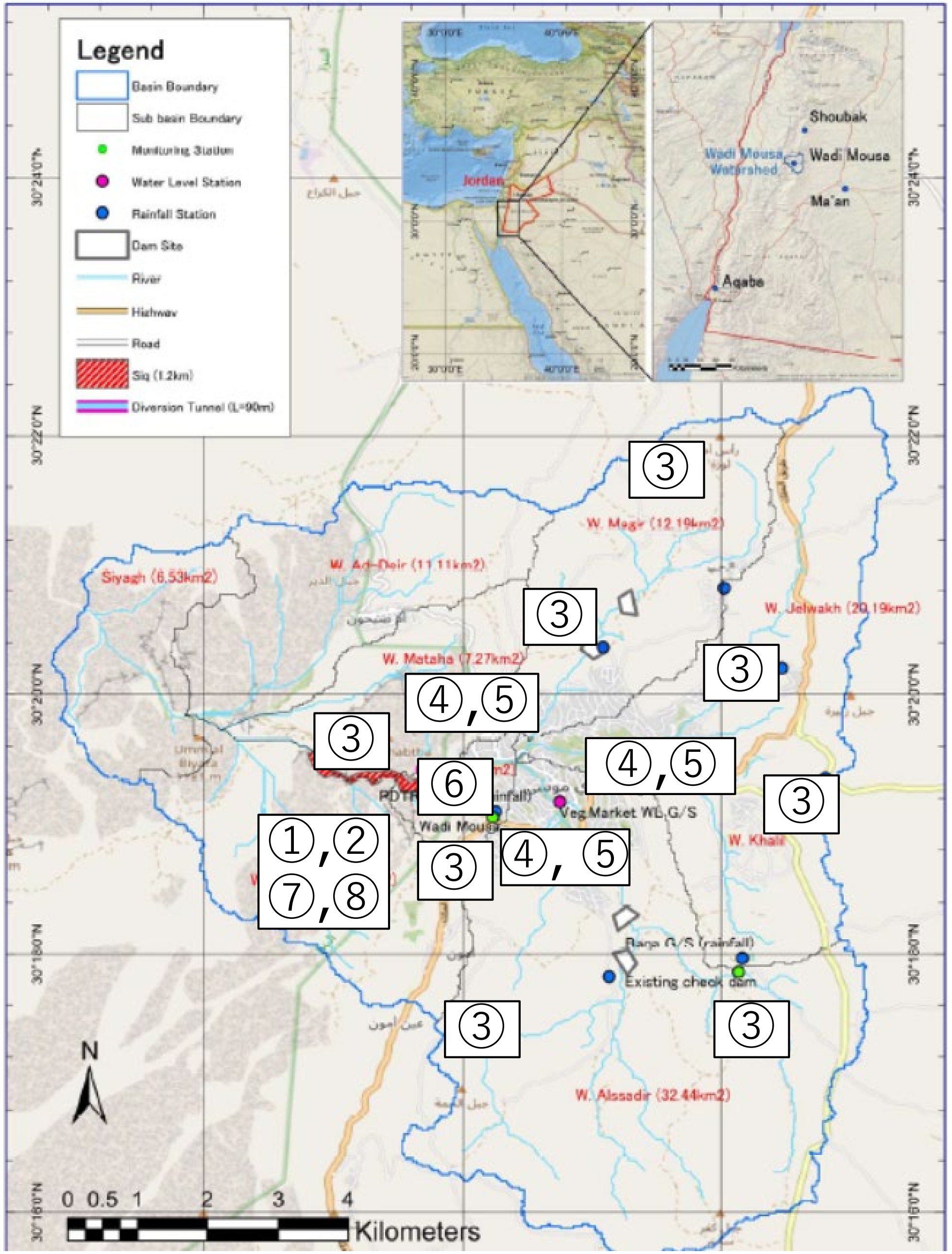
Over far future (2066-2100), it was about **10 times higher**



The historical and future spatial precipitation intensity for 100-year RP







Early Warning System Upgrading

① Satellite Remote Sensing

② Weather radar

③ Ground rain gauge

④ Water level gauge

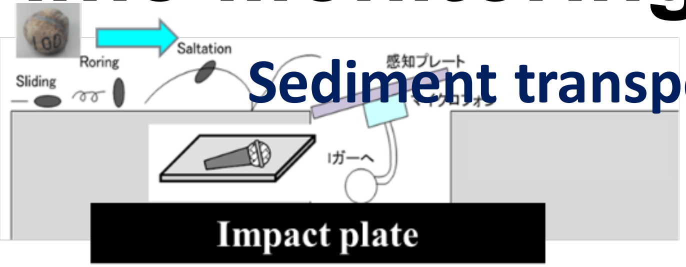
⑤ Flash Flood Impact gauge (Impact Sensors)

⑥ ITV Camera system

⑦ Early Warning Data Analyzing System

⑧ Early Warning Trans-mission system with Siren, ICT(area mail with mobile phone etc.)

Real-Time Monitoring Techniques



Sediment transport

Water Level, velocity, discharge

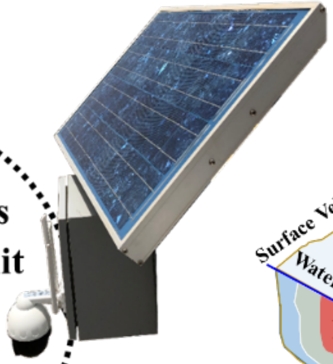
Rainfall/ Radar

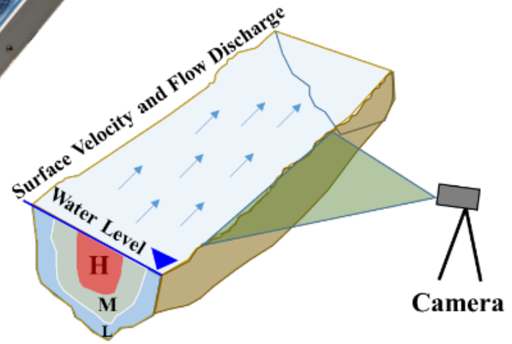
Rain gauge
Transmission unit
Storage unit
Solar power

Impact Sensor

Flash Flood Monitoring Network

Wadi Cameras
Transmission unit
Storage unit
Solar power





AI, Machine Learning

Artificial intelligence and Machine learning

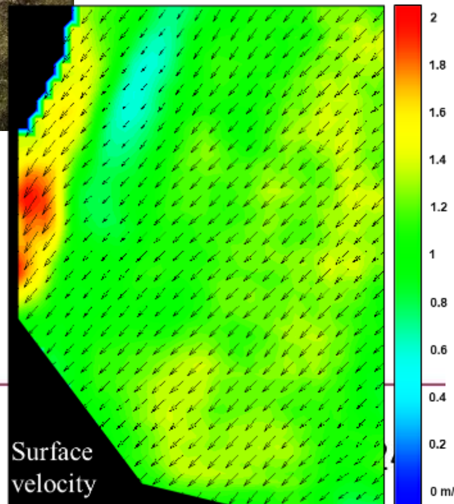
Server System

Data analysis

Image treatment

rning System

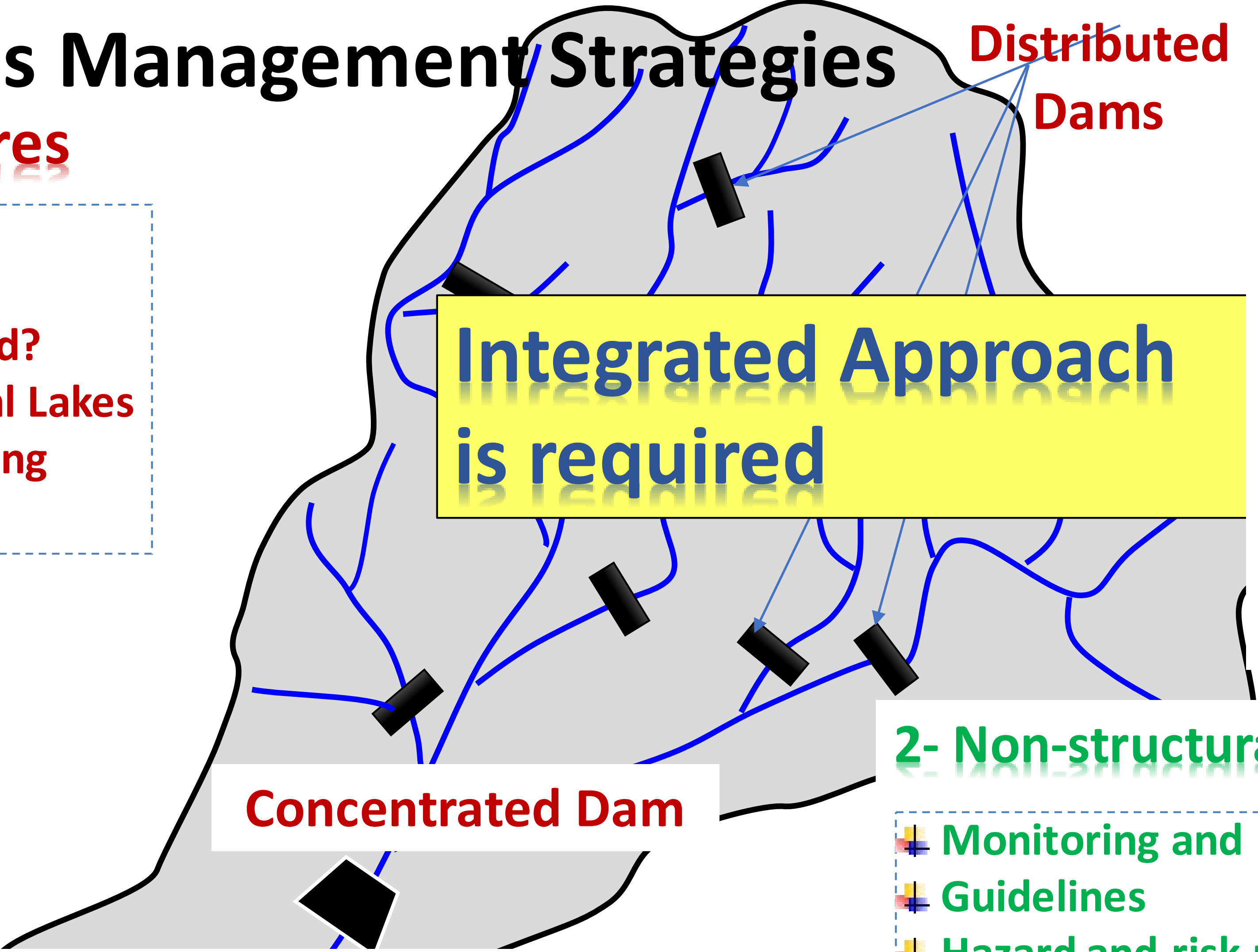
Developing a mobile application



Wadi Flash Floods Management Strategies

1- Structural Measures

- Dams (blockage, storage, retention, recharge)
  Distributed or Concentrated?
- Embankments and Artificial Lakes
- Drainage Channels Improving and Cleaning



3- Water Harvesting

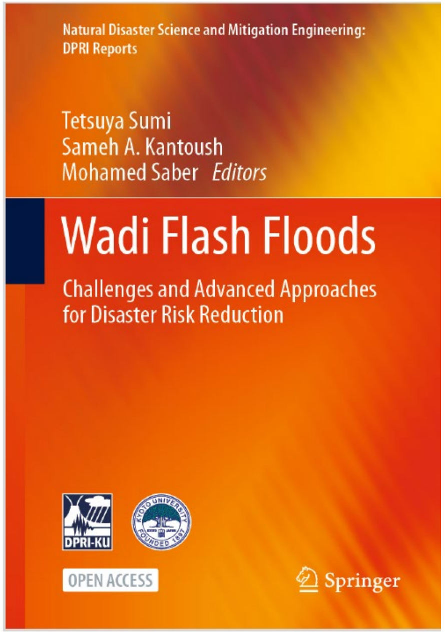
- Temporally water storage
- Groundwater Recharge
- Underground dams
- Agricultural development

1. How can we share available information and data?
2. How can we collaborate among stakeholders, coordinate their tasks, and enhance communication with the residents?
3. How do we create a common platform to understand current conditions and future scenarios?
4. Who will coordinate the discussion and master planning?

2- Non-structural Measures

- Monitoring and Early Warning
- Guidelines
- Hazard and risk maps
- Public Awareness and Education
- Stakeholder engagement and involvement of local communities

Book Details



INTERNATIONAL ORGANIZATION ON CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION MANAGEMENT, INC.

Vision

A vibrant and sustainable partnership on integrated climate change adaptation, mitigation and disaster management

Mission

To create a link between the scientists, the community, and the decision-makers to promote the integration of climate change adaptation, mitigation, and disaster risk reduction management to water resources and river basin management

Goals

- **Provide venues for stakeholder consultations, capacity building and knowledge sharing;**
- **Advise government, policymakers maker and development practitioners;**
- **Undertake collaborative development projects focus on community-based initiatives to mitigate impacts of climate change hazards**

Wadi project proposes a multidisciplinary approach for:

1) **Innovative approaches**: What factors need to be added to the existing approaches for flash floods? How can we enhance the forecasting and mitigation of models and methodologies?

2) **Databased networks**: What are the existing challenges of observation and monitoring networks for modeling and forecasting? How can we enable these ungauged Wadi basins?

3) **Teamwork:** What are the existing global and national networking programs for research collaboration? How can we start efficient networks that include researchers, professionals, engineers, and stakeholders from different countries?

4) **Risk reduction and sediment management**: How can we propose approaches to reducing flash flood risk based on innovative hydrological models and mitigation actions?

5) **Water harvesting and water management**: How can we integrate methods for surface and subsurface water management to harvest water and recharge groundwater?

6) **Society and environment**: How can we develop Wadi societies and communities by involving the local population in research project implementation?

7) **Decision-making, planning, and governance**: How can we improve the existing national and global plan for Wadi society development? Rainfall-Runoff Inundation Model.

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Prediction of flood-sediment hazards in a watershed: focus on rainfall runoff and sediment transport processes

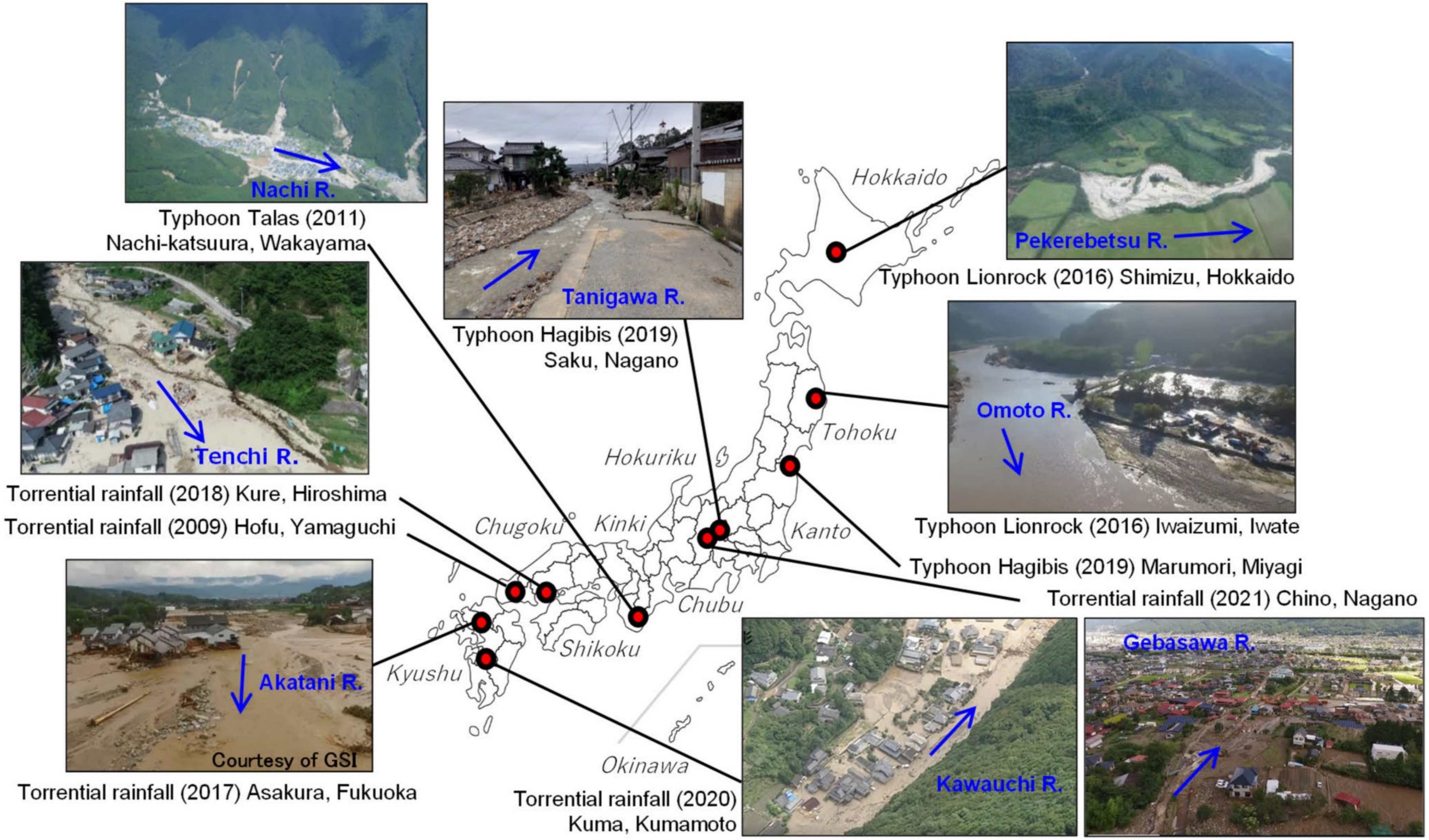
International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM)
Menglu Qin

Centre
Under the auspices
of UNESCO

International Centre for Water Hazard and Risk Management under the auspices of UNESCO

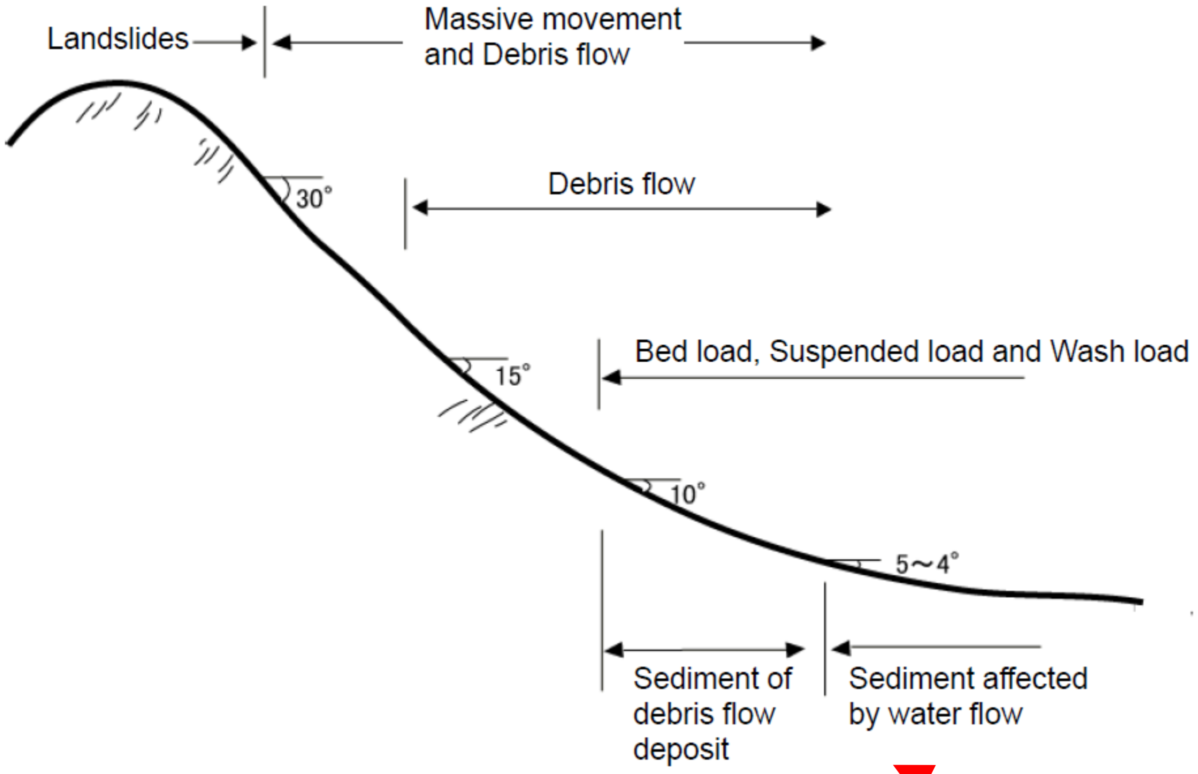
Public Works Research Institute, National Research and Development Agency, Japan

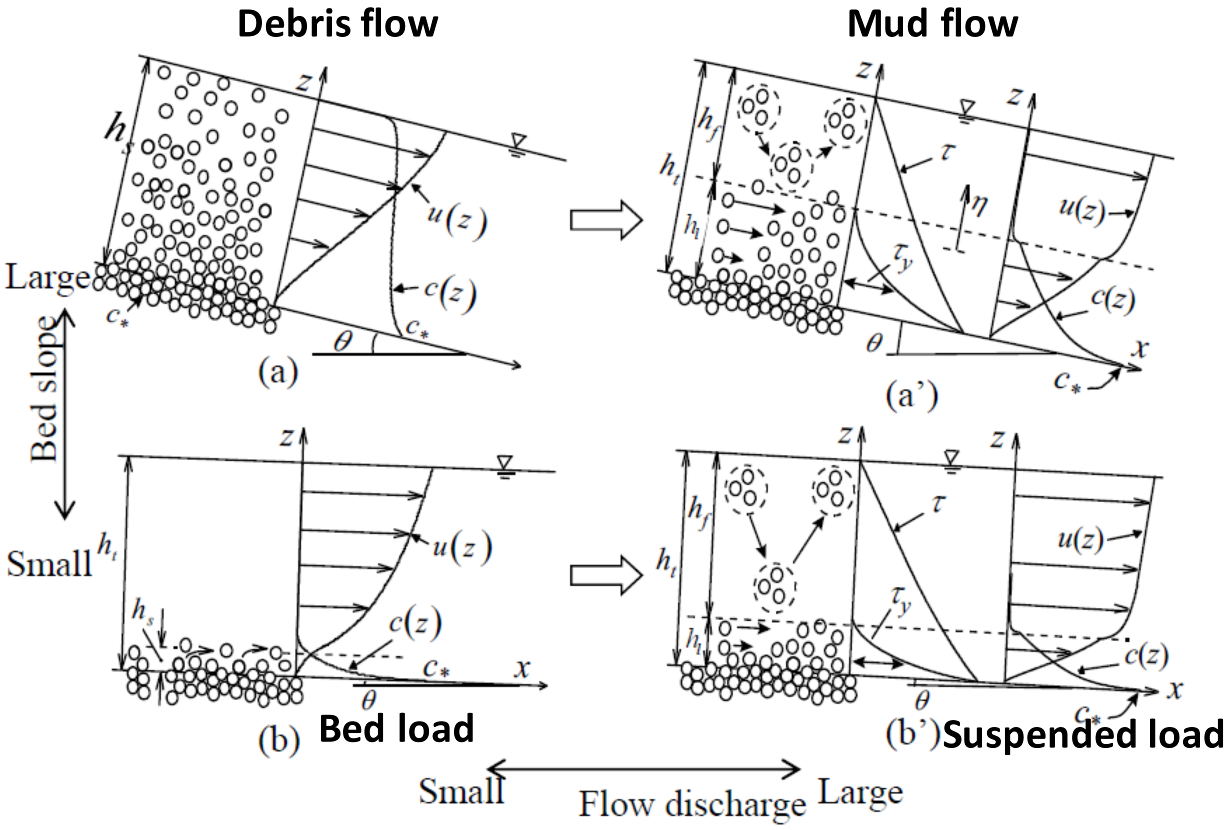
Recent flood hazards with sediment in Japan (2009-2021)



Hayashi, S. I., Kunitomo, M., Mikami, K., & Suzuki, K. (2022). Recent and Historical Background and Current Challenges for Sediment Disaster Measures against Climate Change in Japan. Water, 14(15), 2285.

Sediment transport system in a watershed





Flow regime of sediment and water mixtures

Tackling those sediment phenomena in a determinative point of view

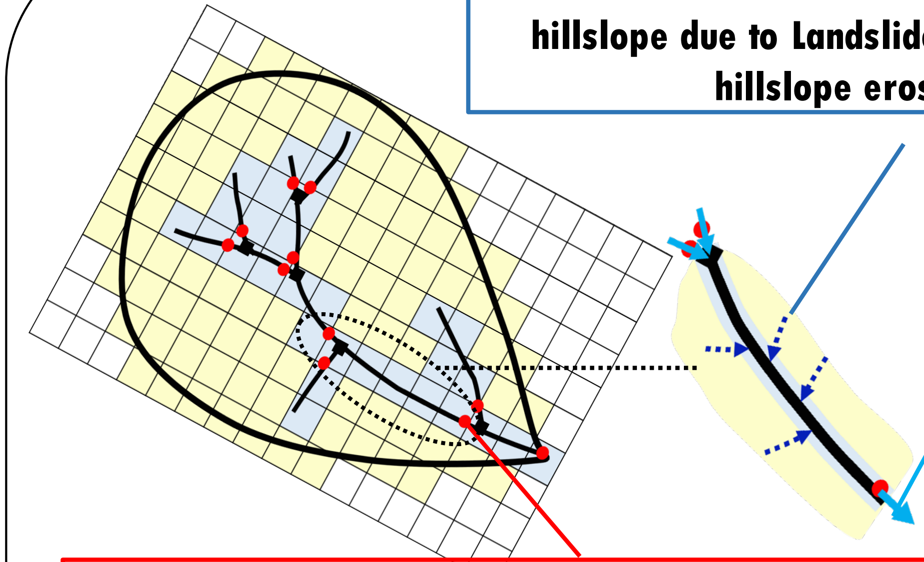
Mechanic based sediment transport theories

Figures provided by Prof. Egashira S.

The structure of rainfall and sediment runoff model (RSR-model)

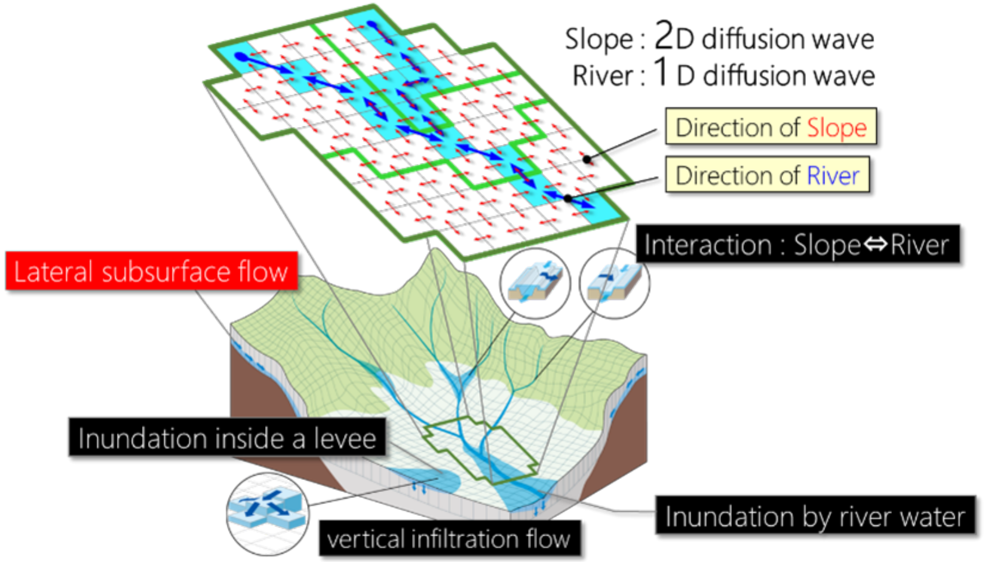
Sediment and driftwood supply from the hillslope due to Landslide/debris flow/ hillslope erosion

Sediment and drift-wood transported through the unit channel networks



Predicting the sediment/driftwood discharge, sediment size distribution, riverbed variation at an arbitrary location

Unit channel model for sediment transport



Rainfall-runoff process (RRI model)

Rainfall and sediment runoff model (RSR-model)

Bridging top-down and bottom-up approaches to address river basin flood-sediment issues

Basin-scale

Rainfall and sediment runoff processes in river basins (RSR-model)

The various flood-sediment hazards and issues in river basins

Upstream boundary conditions

Local-scale

- *2-D flow and bed variation computation*
- *3-D flow and bed variation computation*

Prevention and mitigation of sediment related flood disaster

Inundation disaster with sediment, driftwood

Wide inundation disaster in plain area due to large bank erosion and dyke breach

Comprehensive sediment management in river basins scoped on the issues in dam, river channel, structures and coast management

Sedimentation in dam reservoirs

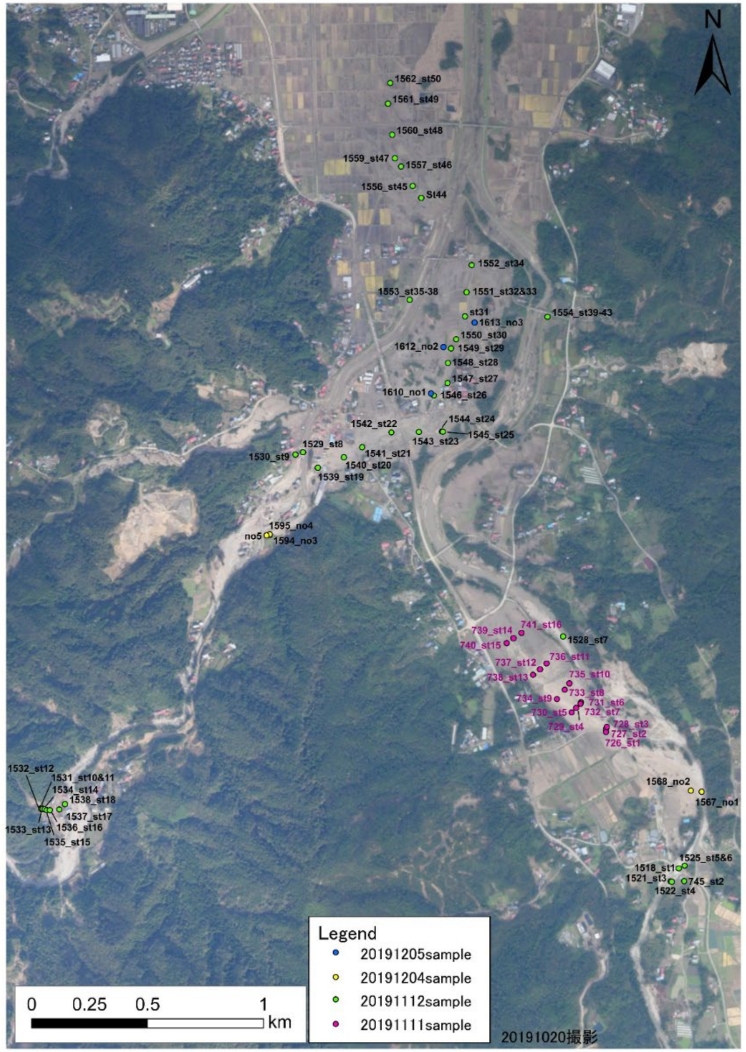
Soil loss in the river basin

The scouring of the bridge pier

Coastal erosion

Prediction of landslide/debris flow and flood-sediment inundation in mountainous rivers

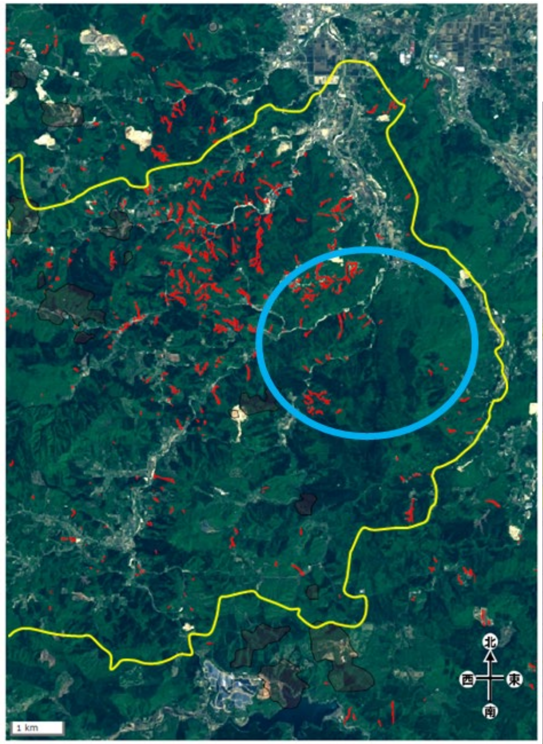
Typhoon Hagibis(2019/10/12-10/13) **Uchi-River Basin(108 km^2), Miyagi Prefecture, Japan**



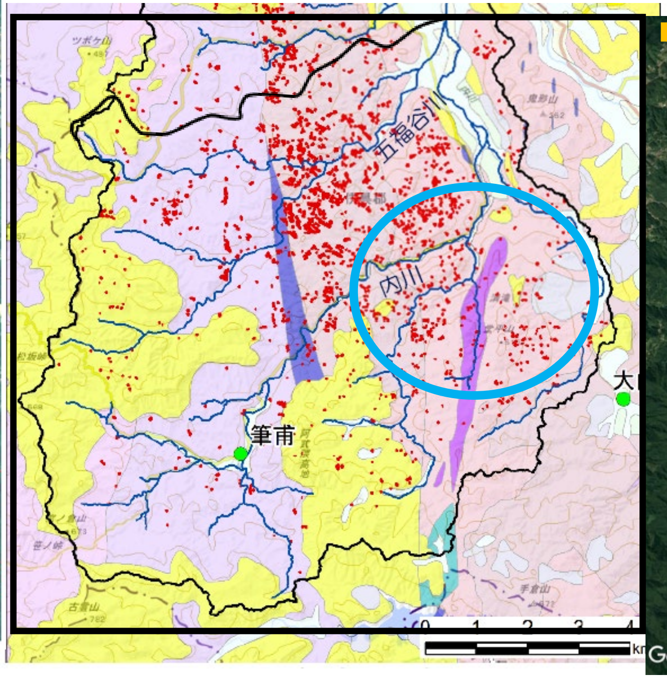
■各支川の中流域で斜面崩壊、土石流等が多数発生。特に五福谷川流域で最も高密度

Report by NILIM

Prediction of spatial distributions of landslide and debris flow

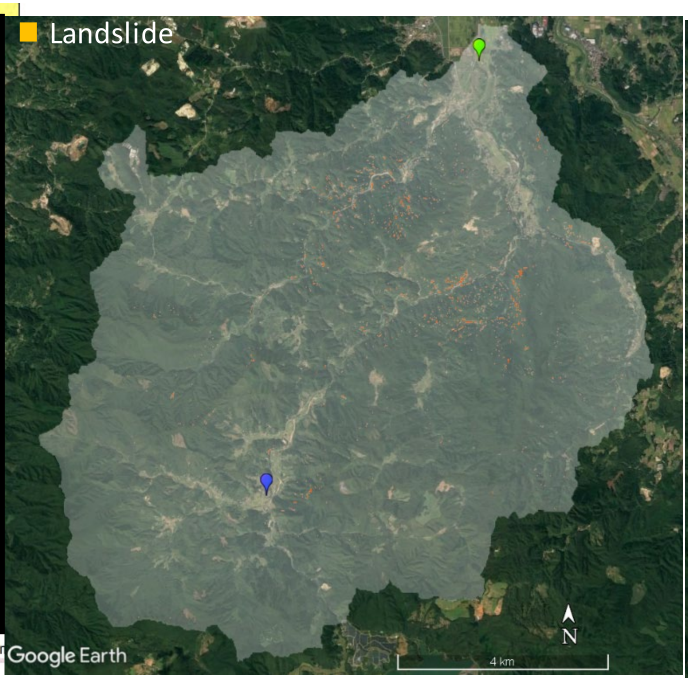


Identified from Arial photos taken 2019/10/12~10/13 (Published by GIA)

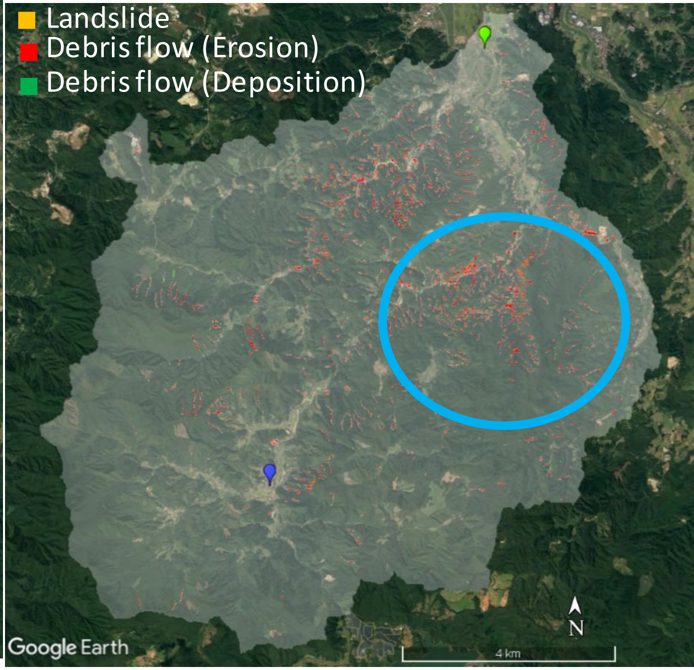


Identified by LP data before vs after ; Yamakage et al. (2020)

Included debris flow traces



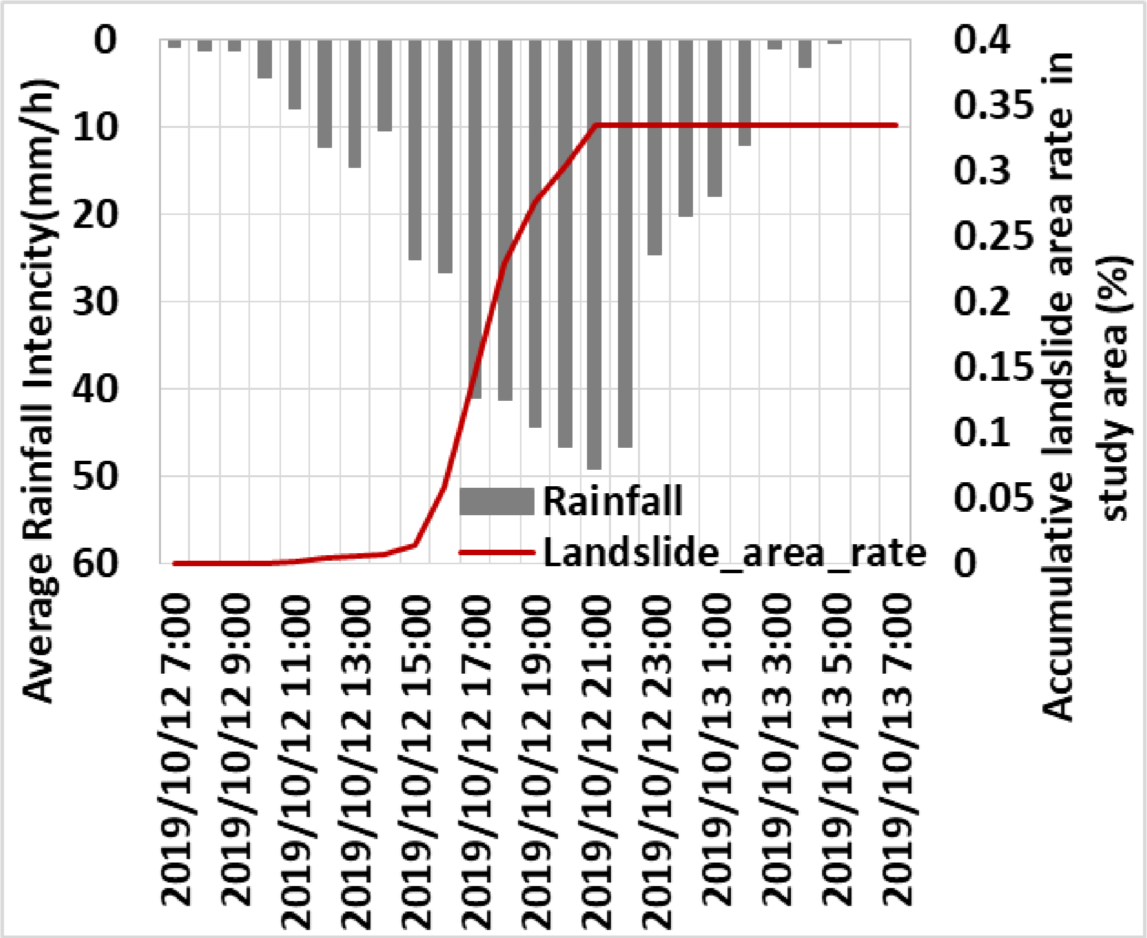
Landslide only

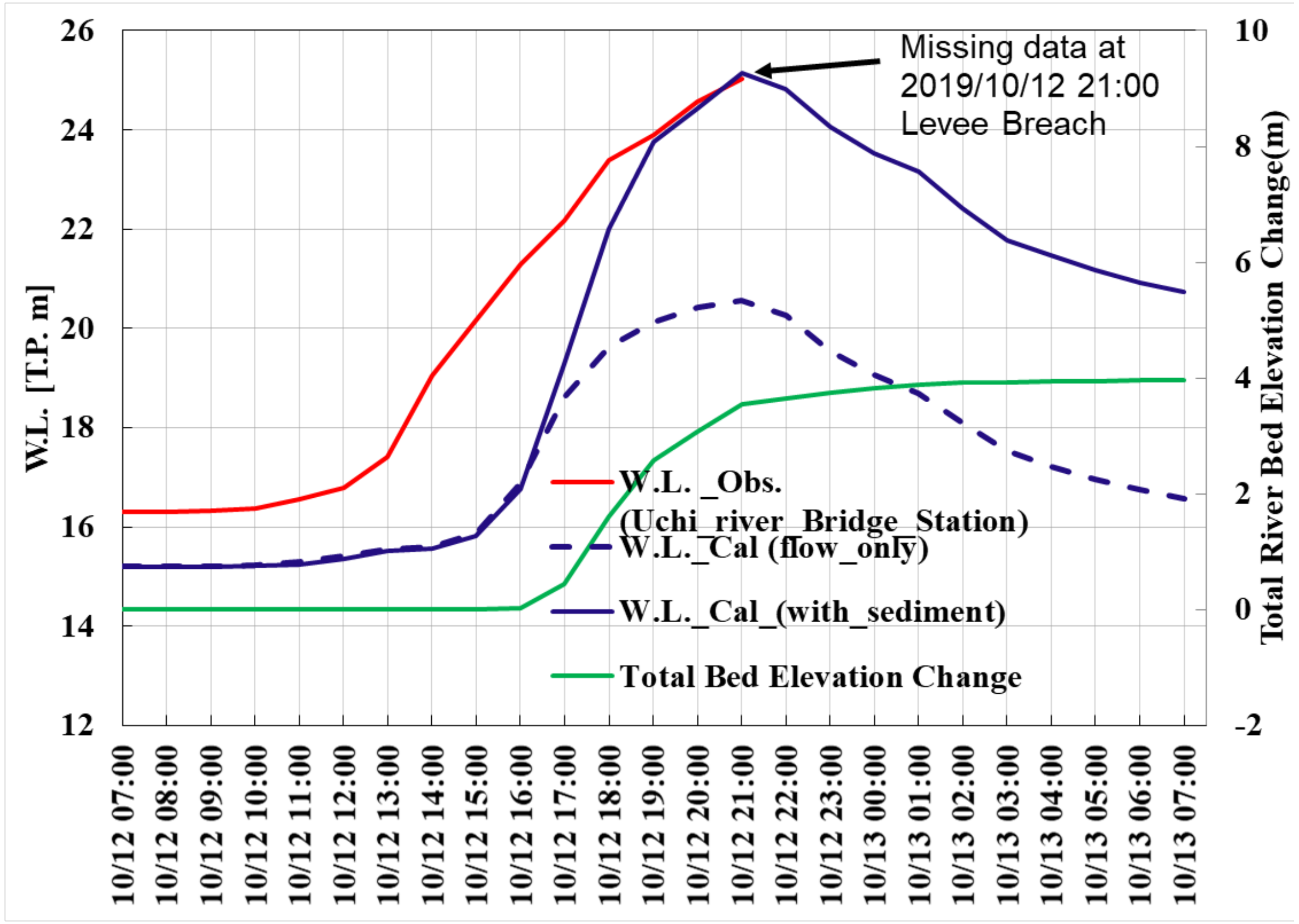


Predicted Results (Including debris flow)

Qin M., Harada D. and Egashira S. : Watershed flood-sediment hazards prediction: focus on rainfall runoff and sediment transport processes, E-proceedings of the 3rd International Symposium of Water Disaster Mitigation and Water Environment Regulation 15-17 November, 2023, Chengdu, China

Prediction of temporal changes of landslides and water level

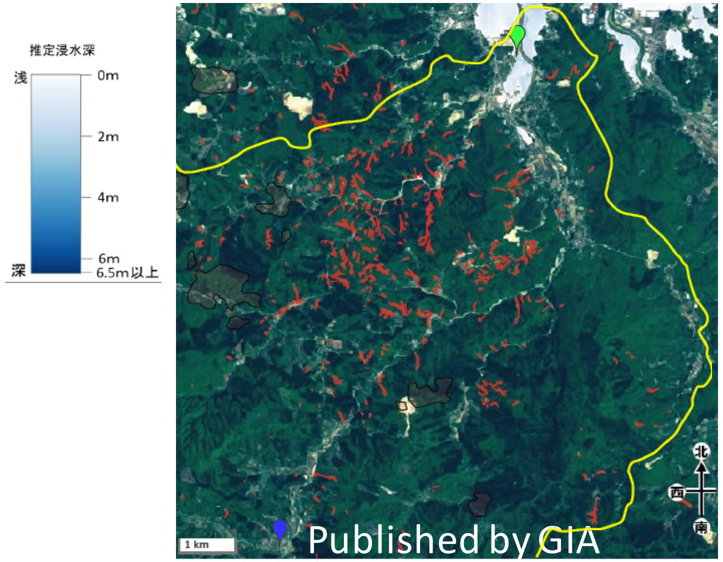




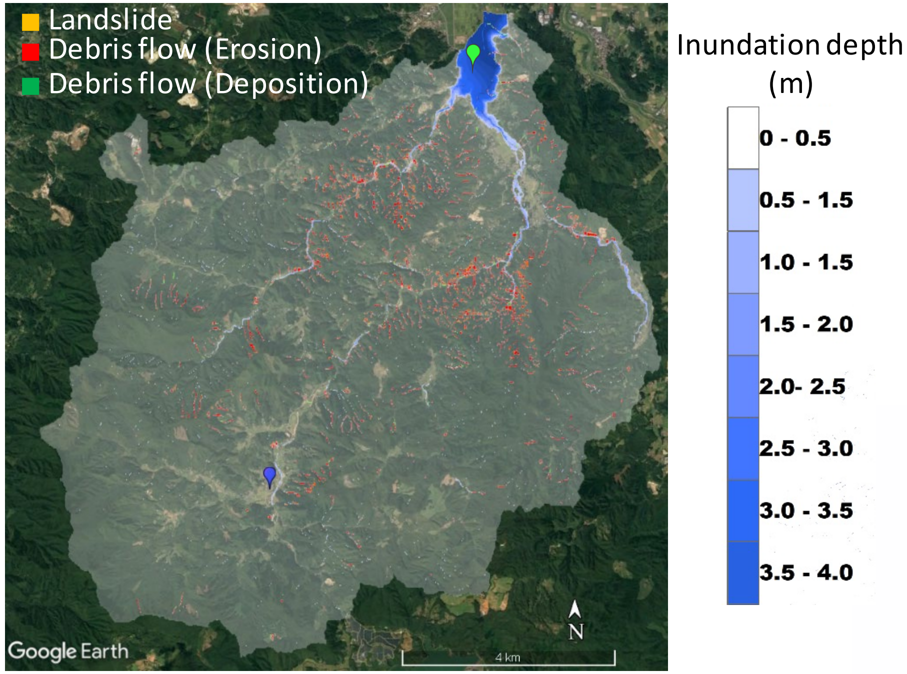
Qin M., Harada D. and Egashira S. : Watershed flood-sediment hazards prediction: focus on rainfall runoff and sediment transport processes, E-proceedings of the 3rd International Symposium of Water Disaster Mitigation and Water Environment Regulation 15-17 November, 2023, Chengdu, China

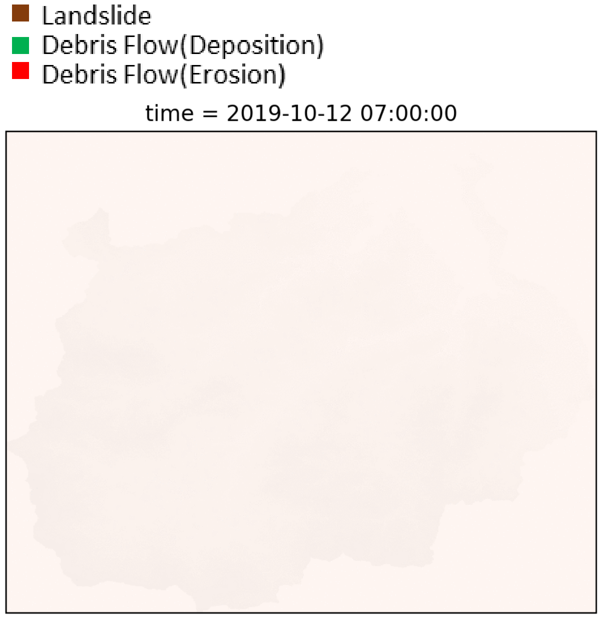
Prediction of inundation extent and depth

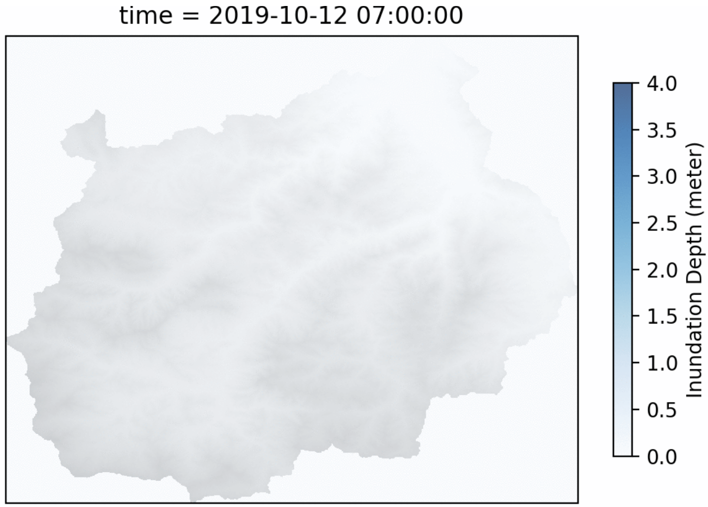
Inundation Extent and Depth
(Mainly Identified by the Ariel photo taken at 2019/10/13)



Peak inundation depth 2019/10/12 23:00(Cal.)



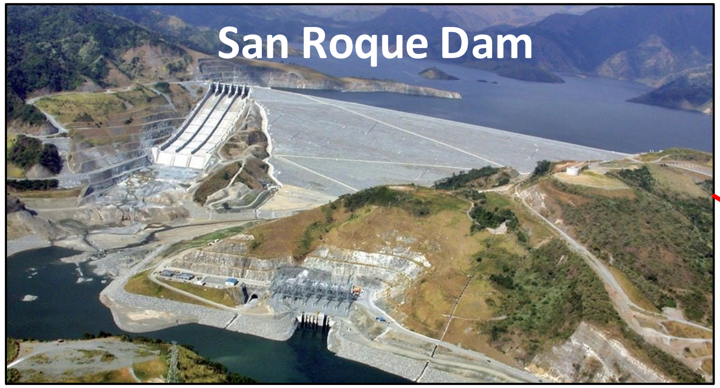


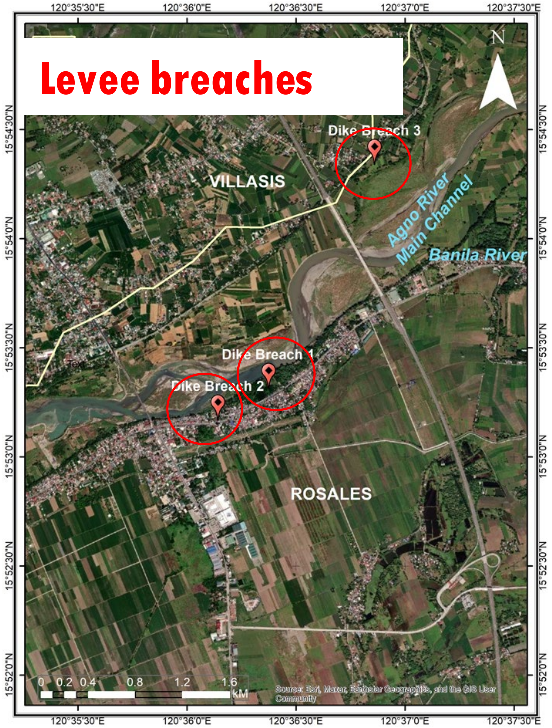


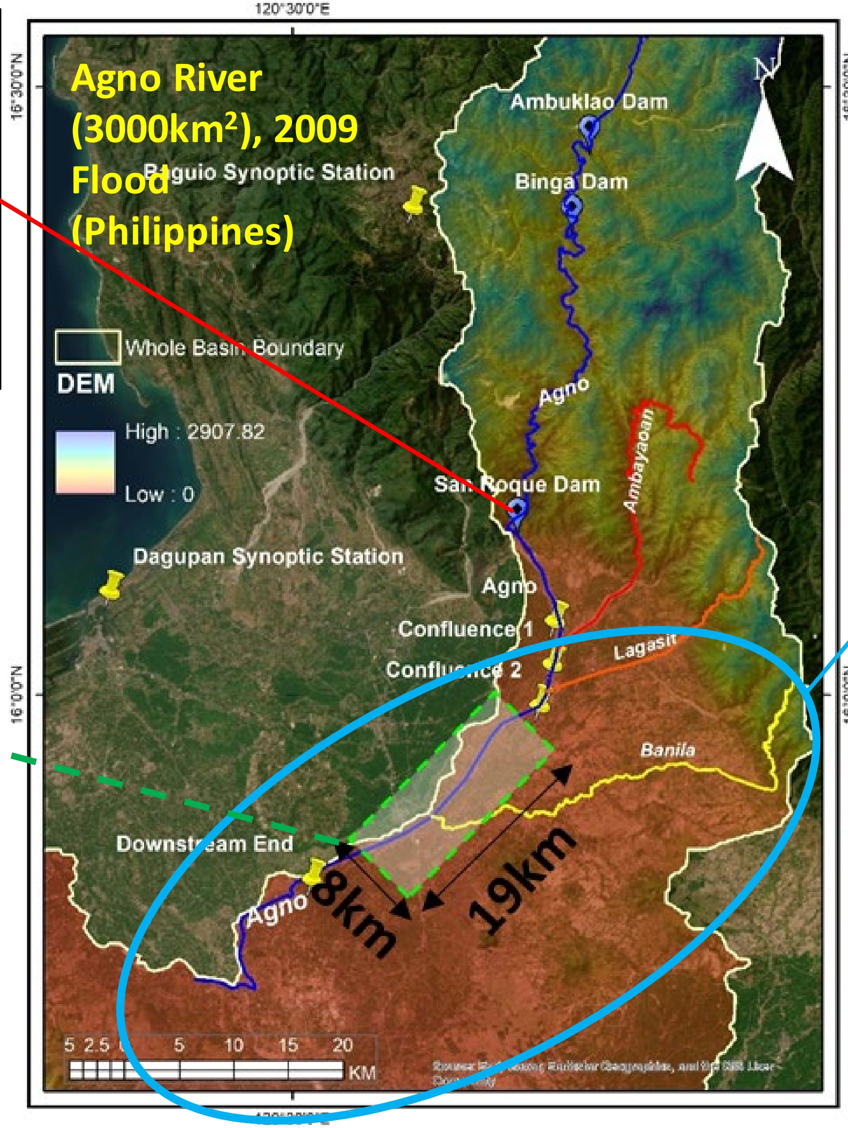
Qin M., Harada D. and Egashira S. : Watershed flood-sediment hazards prediction: focus on rainfall runoff and sediment transport processes, E-proceedings of the 3rd International Symposium of Water Disaster Mitigation and Water Environment Regulation 15-17 November, 2023, Chengdu, China

Prediction of flood and sediment inundation in large plain area

(October 8-9, 2009, Typhoon Parma Agno River, Philippines)







Wide flood and sediment inundation

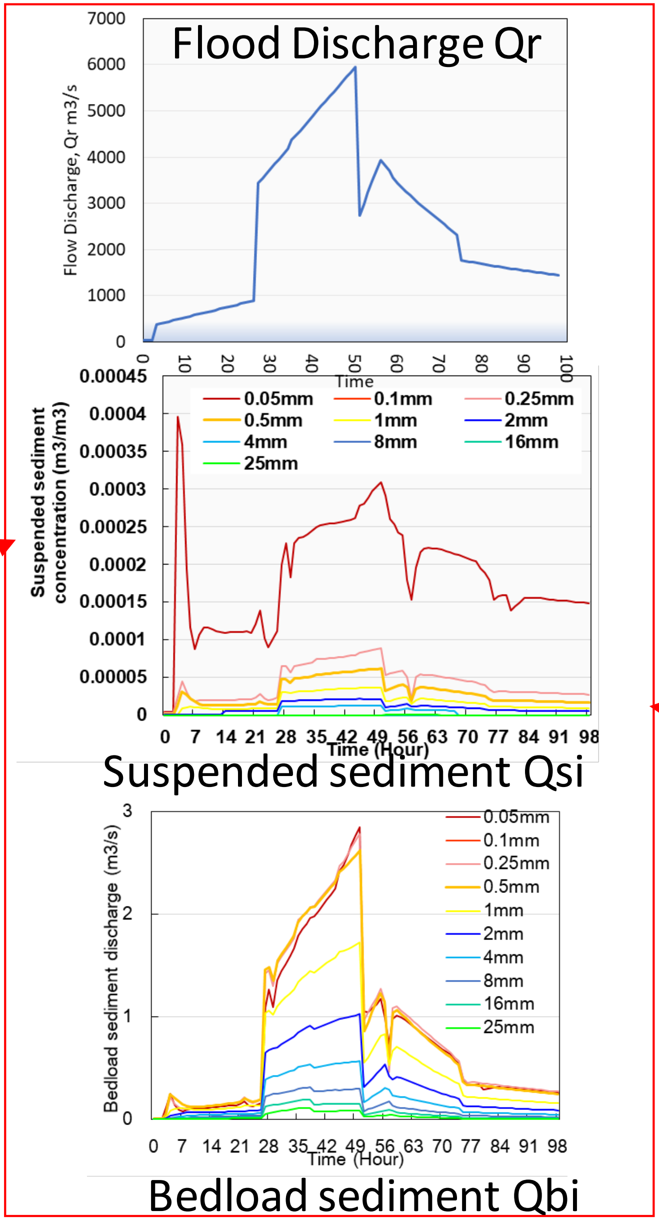
The method of predicting flood and sediment inundation in large plain area

Rainfall and sediment runoff model (RSR-model)

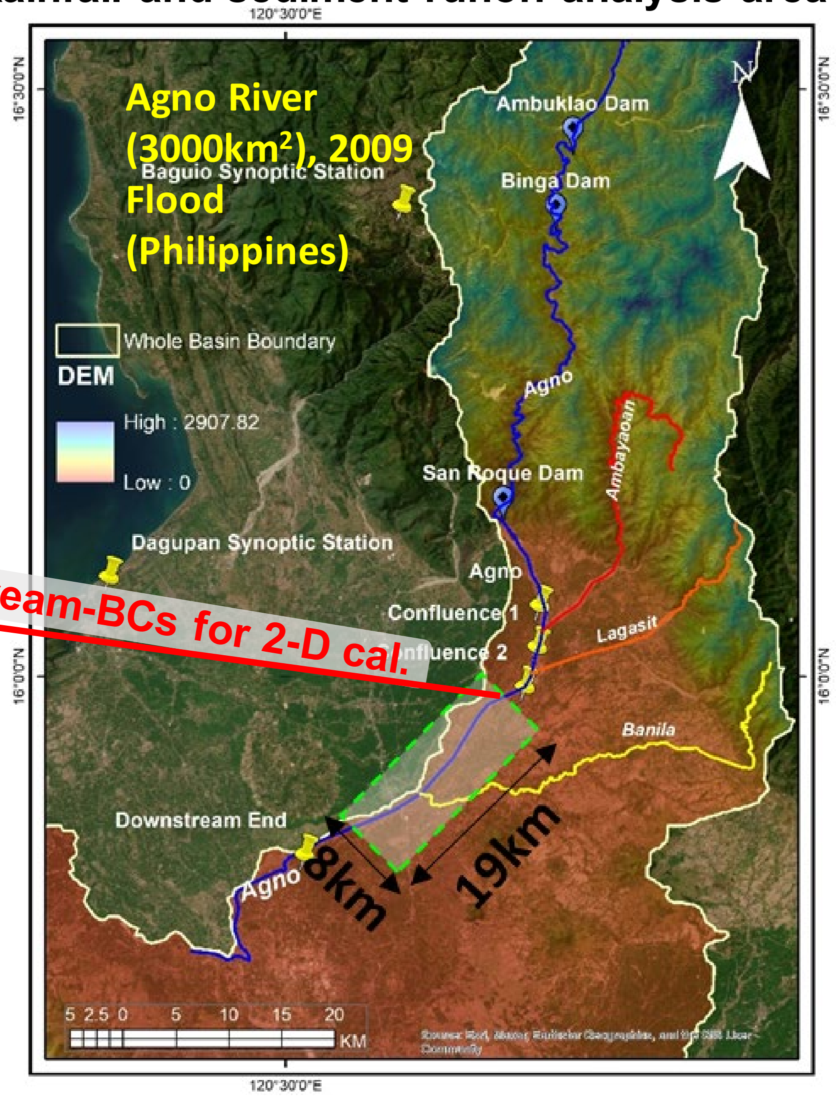
Upstream boundary conditions (inflow flow and sediment discharges of the plain area)

Flood and sediment inundation process estimation

(2-D flow and bed variation-model)

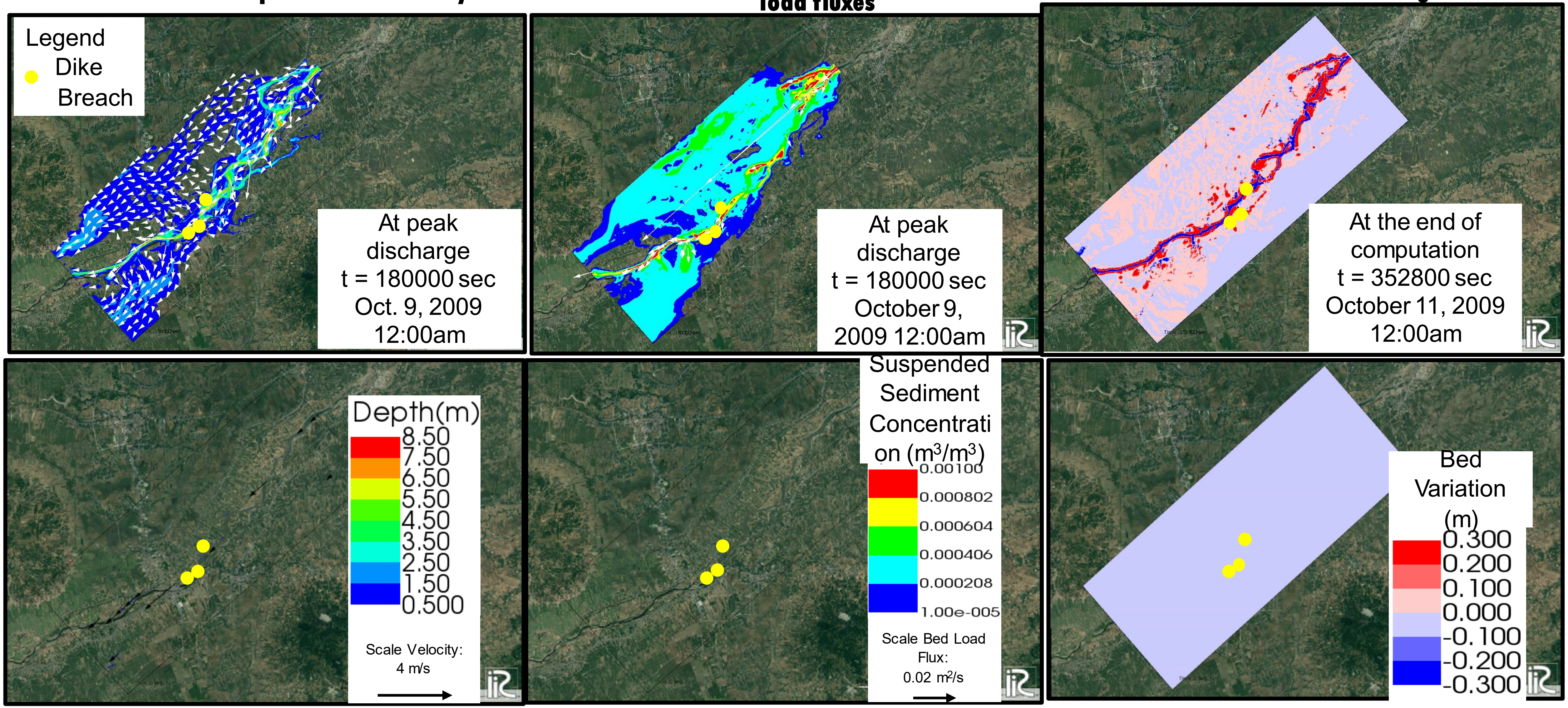


Rainfall and sediment runoff analysis area



Prediction of flood and sediment inundation process

Inundation depth and flow velocity | **Suspended sediment concentration and bed load fluxes** | **Accumulated elevation change**



Conclusions/Messages

・The proposed method can evaluate the dynamic sediment transport processes following the **rainfall runoff process** within a watershed.

⬇

Effective tool for predicting flow and sediment transport behavior in response to extreme rainfall conditions due to climate change

・The proposed method can provide detailed information about the sediment processes (**sediment discharge/ texture/ sorting, transformation among the sediment transport phases**), improving the understanding of the sediment transport phenomenon in a watershed.

⬇

Helping understanding what you are measuring and Guiding what you should measure for the sediment monitoring

・But, to apply on real sediment related flood prediction, more detailed and precise data sets of the initial conditions such as soil depth/GSD, riverbed sediment GSD…must be obtained in advance.

⬇

Re-planning the fundamental data measurement based on the point of view of enhancing the prediction accuracy

Improving the quality and resolution of hazard prediction to bridge the gap between the science community and society on DRR decision-making and action

An Integrated Method to Sediment-flood Hazard Assessment in Watersheds

River Basin-scale

Rainfall and sediment runoff processes in river basins (RSR-model)

Predicting

- *Boundary conditions*
- *Initial conditions*

Local-scale

- *2-D flow and bed variation computation*
- *3-D flow and bed variation computation*

Predicting the various flood-sediment hazards

Science community

Private

Government

- ***Providing high accuracy and resolution of predicted hazard information***
- ***Disaster prevention/ Reduction plan***

Evacuation

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Contributions of the Private Sector to Informed Decision Making

Martin Gomez-Garcia A.

NIPPON KOEI

About the Speaker:

- From La Paz, Bolivia
- Civil Engineer
- Worked 5 years in Bolivia
- Master's and Doctoral degrees from the University of Tokyo
- Joined Japan's largest Civil Engineering Consultant Company in Nov. 2016.
  (Water and Climate Specialist)

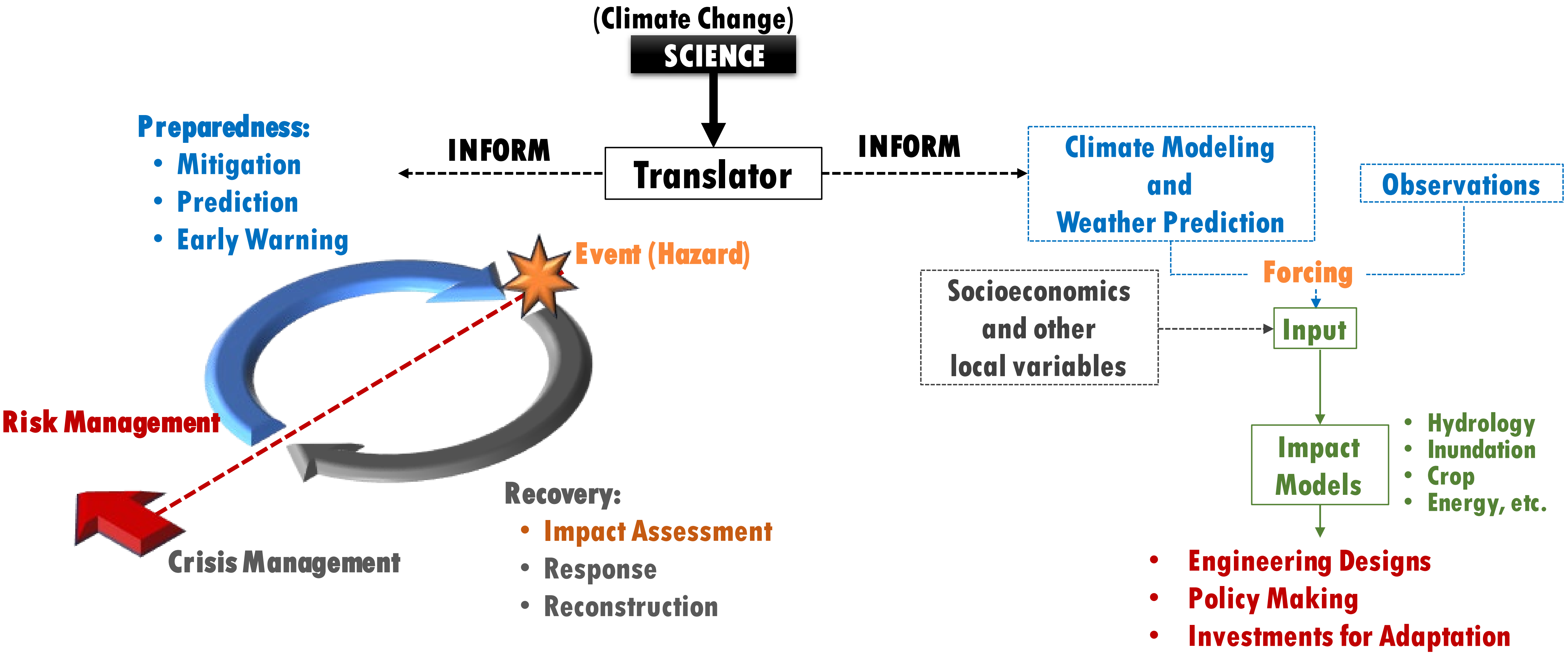
- **Water Resources Management, Climate Change Adaptation, Disaster Risk Assessment**

- Research & Tools Development Knowledge Management Capacity Building

Contribution To Informed Decision-making

Disaster Risk Management

Climate Change Adaptation

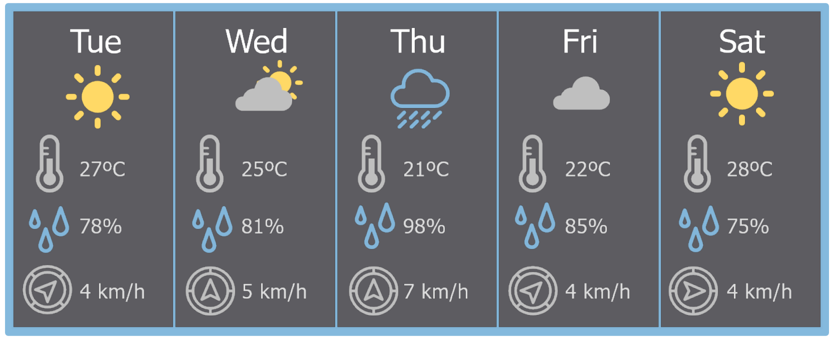


Expansion of Climate Literacy (Examples)

The difference between predicting weather and simulating 21st century climate ----→

Weather

Short-term evaluation of the atmospheric state



This week's weather forecast

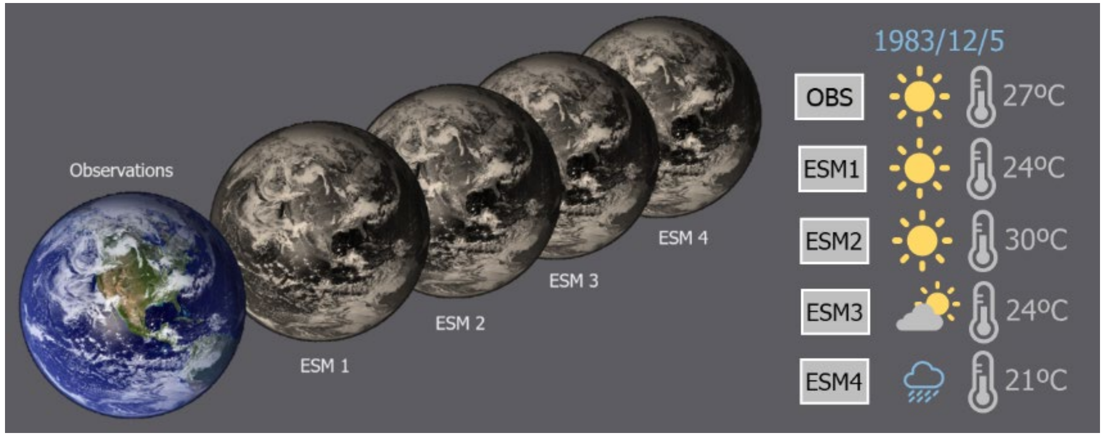
Climate

Long-term evaluation of the atmospheric state

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	21.3 (70.3)	22.6 (72.7)	24.4 (75.9)	29.0 (84.2)	31.4 (88.5)	36.4 (97.5)	37.7 (99.9)	37.7 (99.9)	36.1 (97.0)	33.7 (92.7)	27.4 (81.3)	23.8 (74.8)	37.7 (99.9)
TX	10.7 (51.3)	12.0 (53.6)	15.3 (59.5)	19.9 (67.8)	23.9 (75.0)	26.5 (79.7)	30.3 (86.5)	31.9 (89.4)	28.9 (84.0)	24.1 (75.4)	18.5 (65.3)	13.1 (55.6)	21.2 (70.2)
TG	7.2 (45.0)	8.1 (46.6)	11.2 (52.2)	15.6 (60.1)	19.7 (67.5)	23.0 (73.4)	26.9 (80.4)	28.1 (82.6)	24.9 (76.8)	20.0 (68.0)	14.5 (58.1)	9.4 (48.9)	17.4 (63.3)
TN	4.0 (39.2)	4.5 (40.1)	7.5 (45.5)	11.7 (53.1)	16.1 (61.0)	20.2 (68.4)	24.5 (76.1)	25.3 (77.5)	21.9 (71.4)	16.5 (61.7)	11.0 (51.8)	6.0 (42.8)	14.1 (57.4)
	−5.6 (21.9)	−4.8 (23.4)	−3.6 (25.5)	0.2 (32.4)	5.3 (41.5)	8.9 (48.0)	15.0 (59.0)	16.4 (61.5)	11.1 (52.0)	4.9 (40.8)	−0.2 (31.6)	−3.9 (25.0)	−5.6 (21.9)
PR	63.1 (2.48)	84.0 (3.31)	123.2 (4.85)	153.0 (6.02)	160.7 (6.33)	335.9 (13.22)	292.7 (11.52)	217.9 (8.58)	186.6 (7.35)	102.1 (4.02)	100.7 (3.96)	74.8 (2.94)	1,894.7 (74.59)

1991-2020 Climate Normals of Nagasaki City based on JMA records (borrowed from Wikipedia)

What are climate models (Earth System Models or ESMs)? ----→



Research

- Keeping up-to-date with latest releases or advances in observational datasets and climate simulations
- Verification of Regional Climatologies (Model Performance Evaluation)
- Downscaling Techniques
- Uncertainty Quantification

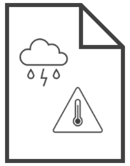
↓ TO BETTER INFORM

- Engineering Designs
- Resilience (Address vulnerabilities)
- Policy Making
- Investments for Adaptation

Research (Uncertainty Quantification)

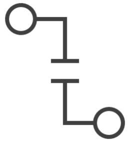
- **Providing climate data to the private sector**

Increased Demand



Business Opportunity

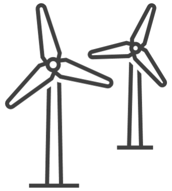
The risk of maladaptation



Although transparency is crucial for end-users, most CSPs fail to address UNCERTAINTY.

- **Sources of uncertainty in climate projections**

Radiative Forcing Uncertainty
(Scenario Uncertainty)



Future societal choices are unknown

Climate Response Uncertainty
(Model Uncertainty)

Limited knowledge
(epistemic uncertainty)

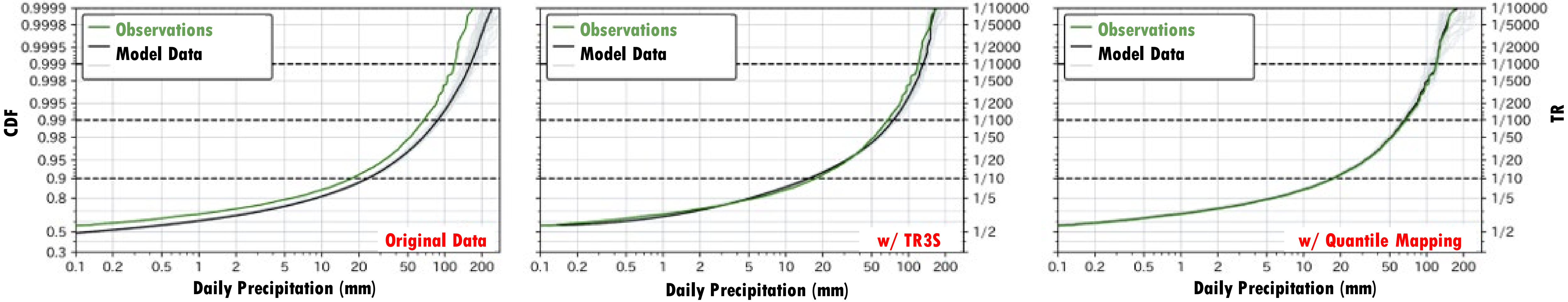
Internal Climate Variations

Natural variability of the atmospheric state (stochastic uncertainty)

Gomez-Garcia, M. and Pui, A. (2024) Demystifying model uncertainty and internal variability in climate change projections over the 21st century, EGU General Assembly.

Research (Bias Correction)

- **Bias Correction** is a process that modifies daily data of future projections of climate based on comparisons made between observations and simulations of past climate.
- Widely used bias-correction methods (Quantile Mapping) can be extremely invasive and unwillingly modify future climatology, interannual variability, and extremes.

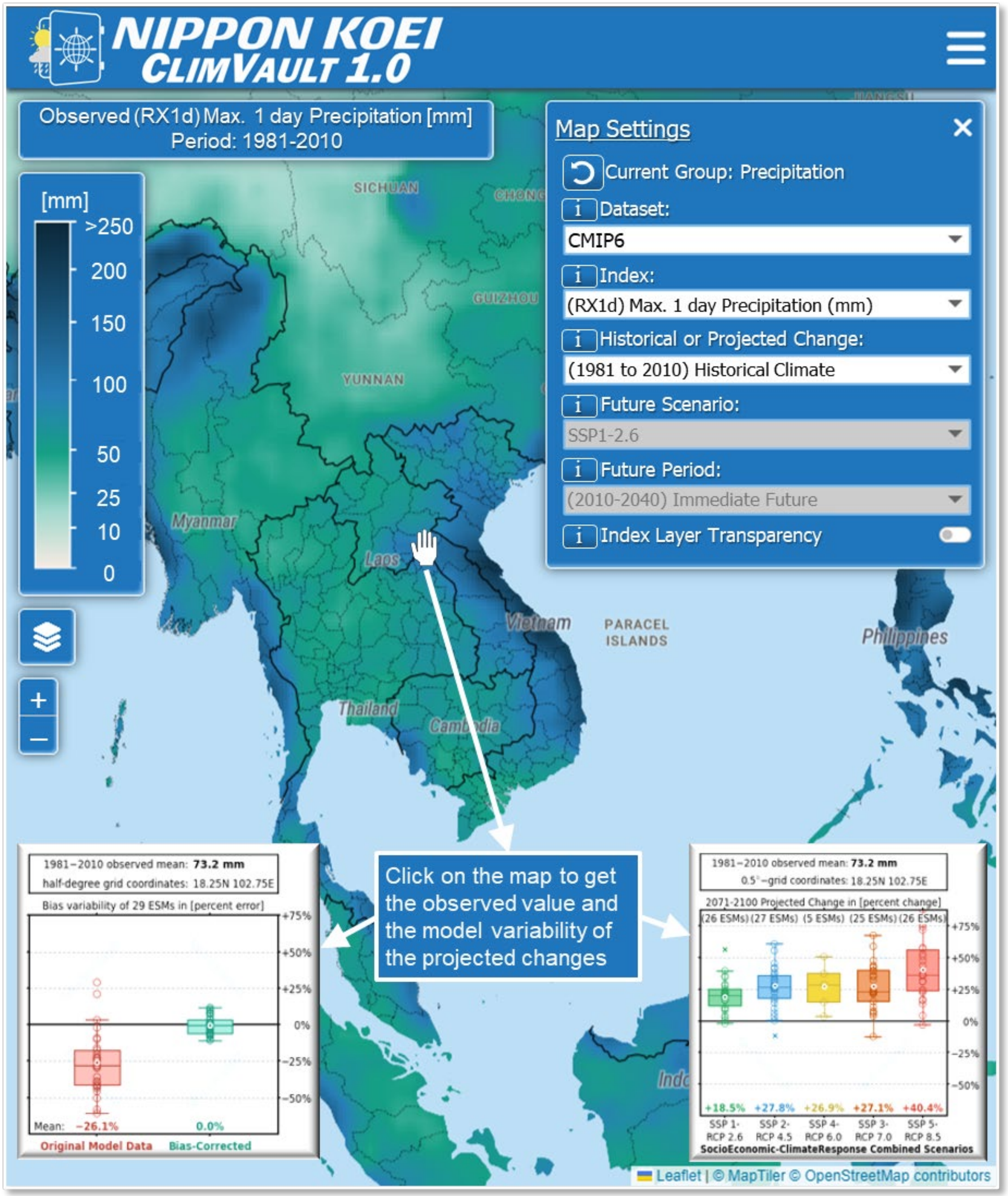


- Consider the climatology, interannual variability, and impact of sampling variability to develop a more comprehensive bias-correction methodology (TR3S method).

Gomez-Garcia, M., et al. (2019). Time scale decomposition of climate and correction of variability using synthetic samples of stable distributions. **Water Resources Research**, 55, 3632–3658.

Tool Development

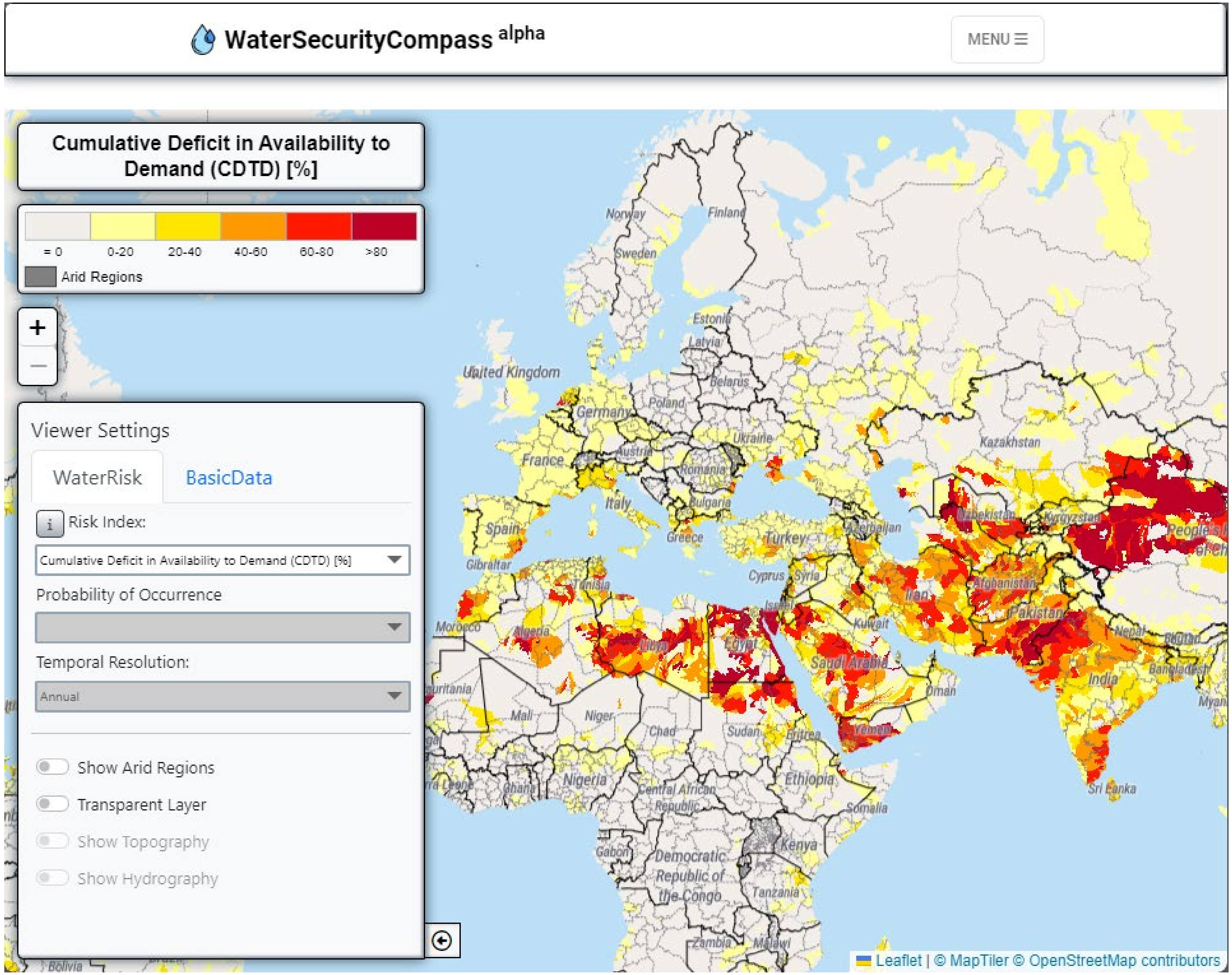
- **To facilitate the rapid access to global projections of climate under different climate change scenarios.**
- **NK-CLIMVAULT: Database of Projected Climate Trends and Weather Extremes.**



Visit our portal at
https://nk-climvault.com/atlas/
We appreciate your feedback.
Contact us to admin@nk-climvault.com

QR code:

Tool Development (coming soon)



WATER SECURITY COMPASS

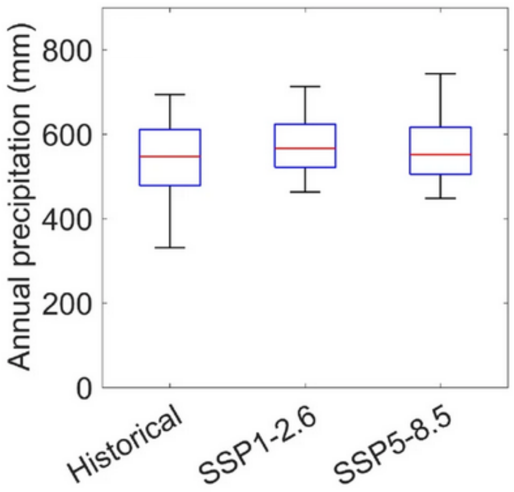
- In collaboration with the University of Tokyo and Suntory Holdings, Nippon Koei is developing a platform of water scarcity metrics.
- Support the reporting of water-related risks and impacts to the water cycle.
- Based on a state-of-the-art global hydrological model.

Communicating Climate Science and Risk

The importance of Understanding Human Behavior:

"…humans have difficulty responding rationally to risks from events that are outside their experience, even when accurate quantitative information on these risks, and the benefits of rational mitigation actions, is available" (Sheperd et al., 2018)

Scientific Reports:



Krøgli et al., 2018

伝統

革新

強靭性

TRADITION • INNOVATION • RESILIENCE

About the Speaker : Sanjeewa Illangasingha

- From Anuradhapura, Sri Lanka
- Chartered Civil Engineer , Works 15 years at Mahaweli Authority of Sri Lanka
- Double Master's from the UNESCO-IHE Delft, Nederland's, and University of Peradeniya, Sri Lanka, 3rd year PhD student at ICHARM/GRIPS, Japan
- Water Resources Planning, Planning & design (soft & Hard) for Climate Change Adaptation and Disaster Risk Reduction (DRR)
- Interesting Water sharing polices and flood and drought monitoring tools

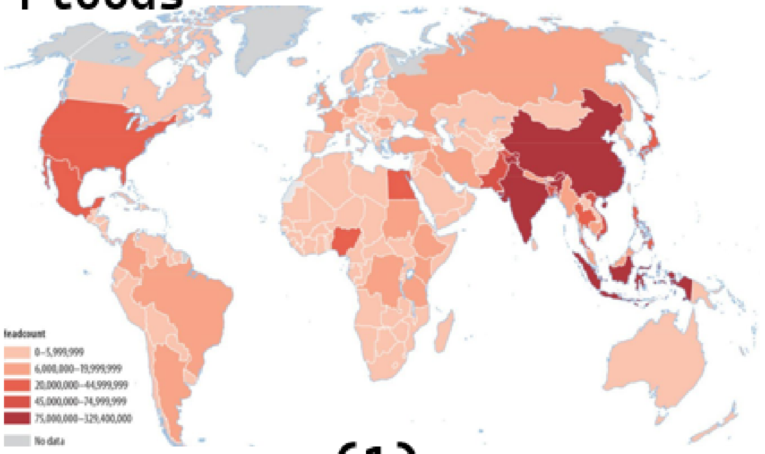
Today Topic:

A HOLISTIC FRAME WORK FOR UTILIZATION OF EXISTING WATER RESOURCES OF INTER BASINS SYSTEM FOR TACKLE THE CLIMATE CHANGE

Situation of the Disasters & Root Causes

- ✓ Tsunami /, Floods, Droughts , Landslides, Land Subsidence ,Cyclones ,Lighting/Thunderstone ,Coastal Erosion , Salinization
- ✓ Earth Quakes , Forest Fire , Heat Wave/Human-made Disasters
- ✓ 74% of natural disasters were water-related (Between 2001 and 2018) (UN WWDR, 2020)
- ✓ Over 90% of natural disasters were water-related in 2023 (UNEP,2024)

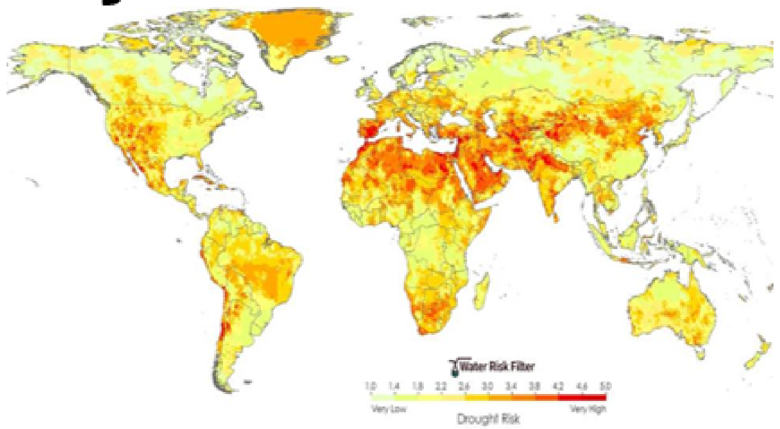
Climate change Impact - Floods



(1)

Millions people exposure to 15cm or more flood inundation risk (Source WB,2022)

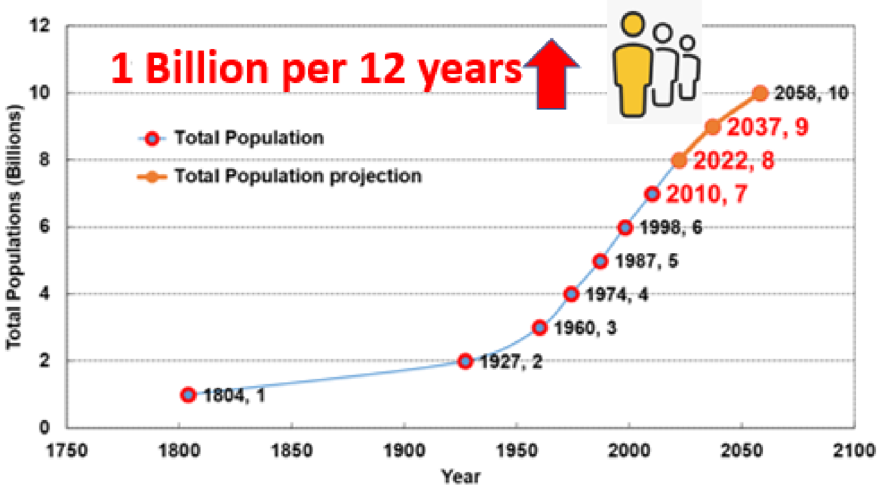
Climate change Impact - Droughts



(2)

1/5% of large cities are at high/very high risk of drought (WWF,2018)

World Populations Increasing



(3)

Rapid increasing of Population (UN Population, 2022)

Requirement of Addressing the DRR policies

1. Sustainable Development Goals / **SDGs (2015)**
2. Paris Agreement / **PA (2015)**
3. Sendai Framework for Disaster Risk Reduction / **SFDRR (2015)**
4. Kumomoto Declaration / **KD 2022**
5. Water Conference 2023 / **WC 2023**

Four Priorities – Understanding Disaster Risk

Climate Change (CC) Disasters

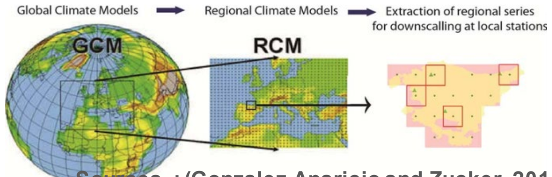
Climate Services for Projecting the Future Climatic variable

There are Gaps for applying science and technology for **CC** on **Decision Making**

Building Sustainable society by strengthen disaster resilience (1) + (3)

(A) Five principles for using global climate model (GCM) outputs in decision-making on climate variabilities

1. The climate models used for decision-making should accurately represent the current regional climate
2. When using GCMs at the regional or local scale, downscaling and bias correction should be implemented
3. The climatic sensitivity of climate models should be identified
4. The disparities in outcomes among climate models should be understood
5. Climate models should be able to address diverse environments



Sources : (Gonzalez-Aparicio and Zucker, 2015)

(B) Five guiding principles aimed at addressing gaps in hydrological analysis for analyzing the influence of Climate change on water availability

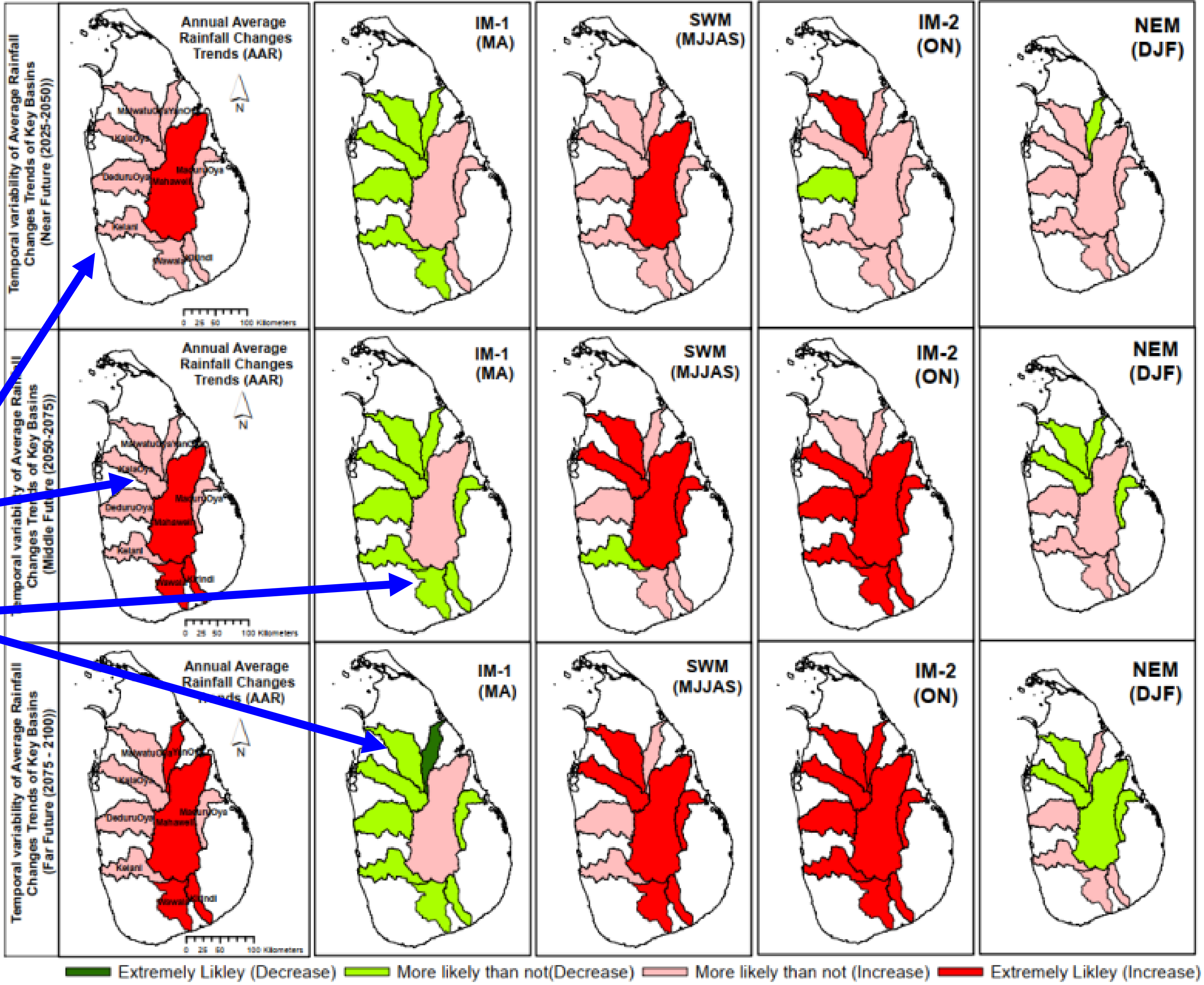
1. Utilize reliable GCM outputs as inputs to hydrological models
2. Seamless - capable hydrology models
3. Climate change features identification: using various hydro-meteorological indices SPI,SSI,SSMI,SETI
4. Recognize key climate change phenomena
5. Diverse environments capability

Rainfall Projection → **Hydrological Parameter** → **Solution by Trans Basin Water Sharing** → **Conclusion**

Future seasonal and annual precipitation likelihood trend for basins

Increasing

Decreasing



For More Details

Climate change (C4) matrix for decision-making

Details of Basins					INSITU (PAST)(1980-2005)					NF (2025-2050)					MF(2050-2075)					FF(2075-2100)				
No	Basin Name	Position with Mahaweli Basin	Basin Specified area	Relevant Climatic Zone	Average Rainfall (mm) / Climate Trend					Likelihood / Simple Average Magnitude % (DOD)														
					PAST					Future Rainfall Trends														
1	Walawa	South	BA	A,D,I,W	375	432	511	363	1674	-3	3	4	3	4	-4	4	5	3	5	-4	5	5	3	5
					0.02	-0.02	0.00	0.01	0.00	-6	26	15	22	12	-20	41	34	24	19	-30	50	55	63	33
2	YanOya	North	BA	D	130	237	415	405	1178	-4	3	4	-3	4	-4	4	3	-3	4	-5	4	5	3	5
					0.04	0.01	0.03	0.00	0.02	-21	22	13	-9	8	-18	45	41	-14	22	-37	72	35	21	22
3	MalwatuOya	North West (North)	BA	D,A	169	210	419	326	1116	-4	4	5	4	[illegible]	-4	5	4	-4	[illegible]	-4	5	5	-3	[illegible]
					0.01	-0.02	0.02	0.00	0.00	-13	21	16	6	[illegible]	-15	49	34	-13	[illegible]	-37	70	42	-20	[illegible]
4	KalaOya	North West	BA	I,D,A	217	213	449	319	1190	-4	3	4	3	[illegible]	-4	5	5	-3	[illegible]	-4	5	5	-3	[illegible]
					0.01	-0.02	0.01	0.00	0.01	-8	37	23	13	[illegible]	-15	49	34	-13	[illegible]	-35	71	58	-20	[illegible]
5	DeduruOya	West	BA	I,W	291	443	558	257	1544	-4	3	-3	3	[illegible]	-3	3	5	3	[illegible]	-4	4	5	3	[illegible]
					0.01	-0.02	0.01	0.00	0.00	-5	28	-3	17	[illegible]	-23	53	28	23	[illegible]	-34	71	51	46	[illegible]
6	MaduruOya	East	BA	I,D	176	261	484	718	1618	3	3	3	3	4	-4	5	5	-3	4	-3	5	5	-3	4
					-0.01	-0.02	0.02	0.00	0.01	5	41	25	9	14	-15	56	32	-12	24	-28	82	53	-18	38
7	Kelani	West (upper)	BA	W	512	1715	848	382	3455	-3	3		3	3	-3	-3	5	3	4	-4	3	5	3	4
					0.00	0.00	0.00	0.00	0.00	[illegible]	10	13	20	13	-24	-7	30	25	21	-31	53	49	62	35
8	KirindiOya	South	BA	A,D,I	284	273	482	315	1347	3	3	4	4	4	-3	4	5	3	5	-4	5	5	3	5
					0.01	-0.01	0.01	0.01	0.01	6	48	14	16	16	-25	62	36	15	23	-30	77	58	53	39
9	Mahaweli	Own	BA	W,I,D	216	497	524	643	1863	3	5	4	4	5	4	5	5	3	5	3	5	5	-3	5
					-0.01	-0.02	0.01	0.00	0.00	8	27	26	24	18	24	45	30	22	25	52	77	47	-27	37

Note

Climate Zones

W	Wet Zone	> 2500 mm / Annum
I	Intermediate Zone	1750 - 2500 mm / Annum
D	Dry Zone	1200 - 1750 mm / Annum
A	Arid Zone	800 - 1200 mm / Annum

BA Basin Avarage

NF - Near Future, MF - Middle Future, FF- Far Future

Probability (likelihood) Occurrence Matrix	% Range	In case of five models
Extremely unlikely	0 - 5 %	0/5
More unlikely than likely	0 - < 50 %	1/5,2/5)
More likely than not	> 50 - 100 %	3/5,4/5)
Extremely Likely	95 - 100 %	5 /5

Seasons		Months
IM1	Inter Monsoon- 1	March-April
SWM	South West Monsoon	May - September
IM2	Inter Monsoon- 1	October to November
NEM	North East Monsoon	December to February
AN	Annual	January to December

Future Trend (agreement of 3 or more GCMs out of 5 selected GCMs) : Increase (+) Decrease (-)

Decrease

Increase

Annual Rainfall Increases

IM-1 Season Rainfall Decrease

SWM Rainfall Decrease

Signal Change

SWM,IM-2, NEM Seasons Rainfall Increase

Integrated Hydrometeorological Indices Analysis: SPI, SSI, SSMI, and SETI Event Projections (Overview)

No	Basin	Wet Condition (short term)								Meteorological and hydrological Drought Condition (Short term)								Agricultural & ecological Drought Condition - long term							
		No of Events Insitu (1980-2005)		NF (2025 - 2050)		MF (2050 - 2075)		FF (2075-2100)		No of Events Insitu (1980-2005)		NF (2025 - 2050)		MF (2050 - 2075)		FF (2075-2100)		No of Events Insitu (1980-2005)		NF (2025 - 2050)		MF (2050 - 2075)		FF (2075-2100)	
		M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S
1	Walawa	11	5							8	2							3	1						
2	YanOya	14	5							5	2							8	0						
3	MalwatuOya	13	7							11	4							9	1						
4	KalaOya	14	5							5	1							9	1						
5	DeduruOya	14	6							7	1							10	4						
6	MaduruOya	12	4							11	6							9	4						
7	Kelani	13	7							13	3							6	1						
8	Mahaweli	12	5							8	2							3	1						

Increasing Trend
Decreasing Trend
NA
M - Moderate event
S - Severe event

Wet Condition - Tendency vary by basin, temporal

Dry – (Drought) Tendency Not so Clear, Uncertainty

Flood Damage on Paddy

High Sensitivities of Paddy Damage

Increasing Flood Damage on Paddy

				GCMs																	
				1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	NF	MF	FF
1	Walawa	235	2.8	-7	-67	15	64	-2	64	[illegible]	59	202	74	-42	21	16	220	-2	- 3	+ 4	+ 3
2	YanOya	265	5.4	9	9	69	71	39	70	-6	200	69	57	47	-45	266	14	56	+ 5	+ 4	+ 4
3	MalwatuOya	556	2.7	-1	645	233	58	65	22	723	386	86	397	-15	740	98	19	246	+ 4	+ 5	+ 4
4	KalaOya	655	3.4	-21	177	1	20	119	132	272	-9	90	742	-15	180	2	82	377	+ 4	+ 4	+ 4
5	DeduruOya	712	5.0	9	-14	38	7	17	77	18	-7	48	68	42	-2	53	28	56	+ 4	+ 4	+ 4
6	MaduruOya	120	4.2	14	-14	0	0	0	29	14	0	50	17	0	-14	0	67	0	+ 3	+ 4	+ 3
7	Kelani	169	34.6	13	-22	-14	22	9	28	4	-7	42	32	1	10	-3	43	7	+ 3	+ 4	+ 4
8	Mahaweli	1201	13.5	-2	-13	58	17	47	47	-31	67	38	58	81	-10	7	73	20	+ 3	+ 4	+ 4

Sensitivity

- Degree of Difference of Damage increase (0 - 25 %)
- Degree of Difference of Damage increase (25 - 50 %)
- Degree of Difference of Damage increase (50 - 100 %)
- Degree of Difference of Damage increase (100 % <)
- Degree of Difference of Damage decrease (0 - 25 %)
- Degree of Difference of Damage decrease (25 - 50 %)
- Degree of Difference of Damage decrease (50 - 100 %)
- Degree of Difference of Damage decrease (100 % <)

Trends

- Increase
- Decrease
- Same

Demand site coverage

Example-Two Demand Sites + GCM (CNRM-CM5)

A) Without Diversion Demand Site Coverage - Past (1990 -2015) - Yala Season

Basin	Demand Site	No of seasons				
		Water Demand Coverage Percentage (sufficient / Insufficient)				
		100%	75 - 99%	50 - 75%	25 – 50 %	0 - 25 %
MalwatuOya	Anuradhapura-WB	9	0	0	2	5
KalaOya	H-Kalawewa	2	0	3	7	4

B) Without Diversion Demand Site Coverage - Near Future (2025 – 2045) - Yala Season (CNRM-CM5)

Basin	Demand Site	No of seasons				
		Water Demand Coverage Percentage (sufficient / Insufficient)				
		100%	75 - 99%	50 - 75%	25 – 50 %	0 - 25 %
MalwatuOya	Anuradhapura-WB	6	0	0	0	14
KalaOya	H-Kalawewa	1	0	1	12	6

Without Diversion

A) With Current Diversion Demand Site Coverage - Past (1990 -2015) - Yala Season

Basin	Demand Site	No of seasons				
		Water Demand Coverage Percentage (sufficient / Insufficient)				
		100%	75 - 99%	50 - 75%	25 – 50 %	0 - 25 %
MalwatuOya	Anuradhapura-WB	16	0	0	0	0
KalaOya	H-Kalawewa	16	0	0	0	0

B) With Current Diversion Demand Site Coverage - Near Future (2025 – 2045) - Yala Season (CNRM-CM5)

Basin	Demand Site	No of seasons				
		Water Demand Coverage Percentage (sufficient / Insufficient)				
		100%	75 - 99%	50 - 75%	25 – 50 %	0 - 25 %
MalwatuOya	Anuradhapura-WB	20	0	0	0	0
KalaOya	H-Kalawewa	20	0	0	0	0

With Current Diversion

With Current Diversion (PAST + Future (GCM) CAN_ESM2,CNRM_CM5)

Basin	Demand Site	Coverage Summary - Number Seasons (Water Sufficient/insufficient)																																																																			
		Yala Season (SWM)																				Maha Season (NEM)																				Yala (SWM)															Maha Season (NEM)														
		PAST					GCM1-CNRM-CM5															PAST					GCM1-CNRM-CM5															GCM2-CanESM2															GCM2-CanESM2														
		(1990-2015)					NF(2025-2045)					MF(2050-2070)					FF(2075-2095)					(1990-2015)					NF(2025-2045)					MF(2050-2070)					FF(2075-2095)					NF(2025-2045)					MF(2050-2070)					FF(2075-2095)					NF(2025-2045)					MF(2050-2070)					FF(2075-2095)				
		Coverage Percentage /(%)																																																																				
		100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25	100	99-75	75-50	50-25	<25
Malwatuoya	Anuradhapura-WB	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
MaduruOya	B-Maduru Left Bank	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	C1,C2-Ulhiiya/Rathkinda	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	D1-Giritale	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	D1-Kantale	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	D1-Kaudula	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	D1-Minneriya	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	D2-ParakramaSamudyara	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
KalaOya	Dambulla-WB	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
KalaOya	Eppawala-WB	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
KalaOya	H-DambuluOya	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
KalaOya	H-Kalawewa	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
KalaOya	H-Kandalama	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
KalaOya	H-Rajanganaya/Neela.	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
MalwatuOya	IH-Nachchaduwa	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
MalwatuOya	IH-Nuwarawewa	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
MalwatuOya	IH-Thisawewa	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
YanOya	KH Feeder Canal	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0
YanOya	MH-Huruluwewa	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	Peradeniya-WB	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	A- Allai	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	E - Minipe	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	20	0	0	0	0	19	0	0	0	0
Mahaweli	G -Elehera	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	16	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	20	0	0	0	0	19	0	0	0	0

✓ 100 % coverage Yala & Maha Season

✓ unmet demand = 0

Deficit Yala Season | Deficit Maha Season | 100 % Coverage

Conclusion & Policies Proposal

- ✓ GCM sensitivity varies spatially and temporally
- ✓ More flood damages on paddy in future
- ✓ Drought projection involved more uncertainty specially in agricultural drought
- ✓ A simple detailed climate analysis chart may better communicate scientific messages to the scientific community and the public decision-makers.
- ✓ Socio-Economic direct benefits due to inter-basin(adjacent basins) water transfers for donor and recipient basins
- ✓ Climate change impacts can be mitigated by water sharing and utilization of existing water storages (resources) of the basins interconnected system

This proves that water-sharing systems can enhance societal robustness even under climate change scenarios

- ✓ **Develop a Holistic Analysis System**
- ✓ Establish or strengthen an integrated basin management authority
- ✓ Enhance Climate-Resilient Infrastructure
- ✓ Introduce automated water management and distribution system
- ✓ Promote International Collaboration

伝統 革新 強靭性

TRADITION • INNOVATION • RESILIENCE

Thank you !

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Question:

What do you think is the most important lesson you have learned from Japan regarding disaster risk reduction?

Suggestion:

Through your experience, please suggest issues that Japan should address in the future to reduce disaster risks.

伝統

革新

強靭性

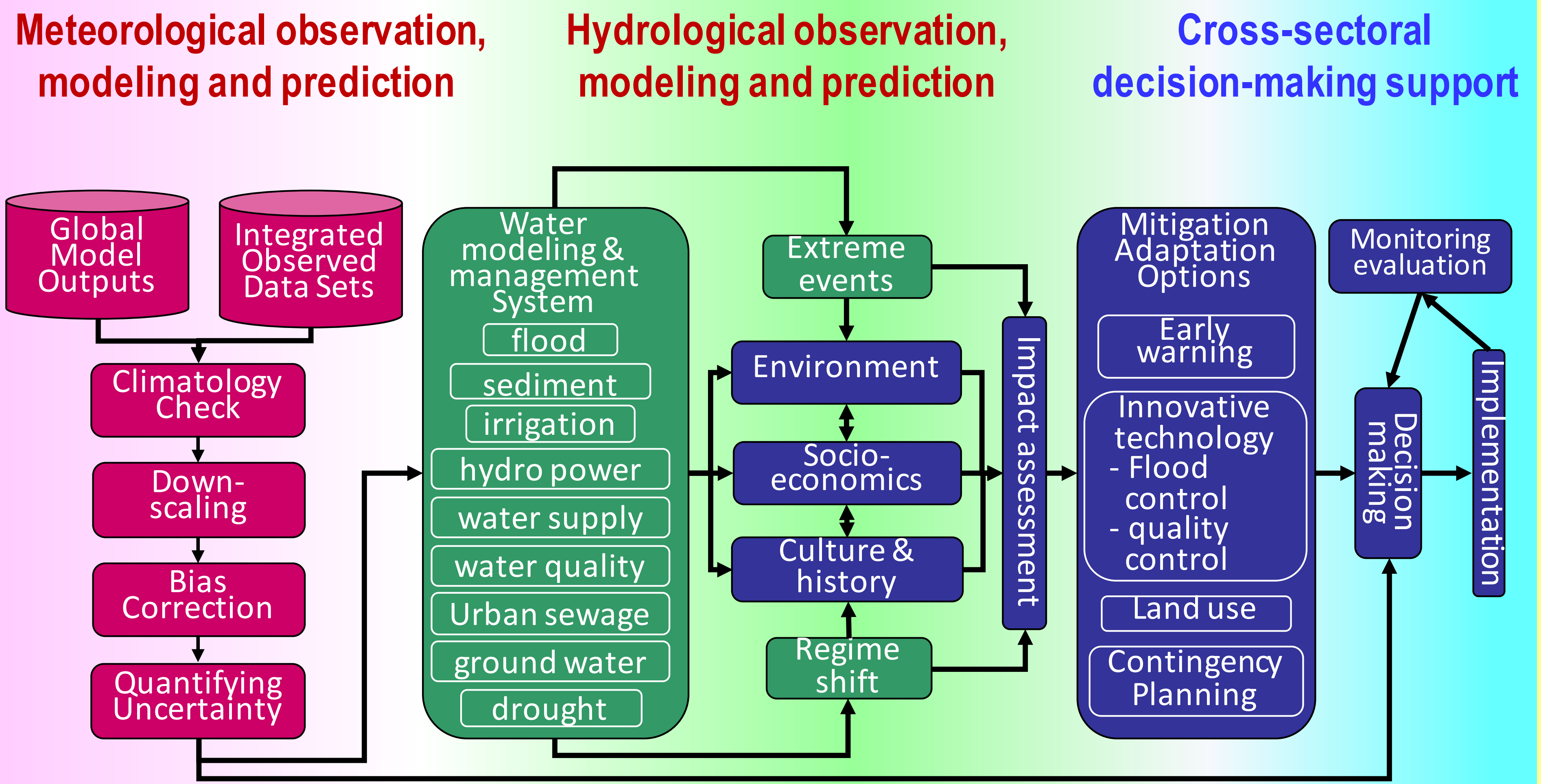
TRADITION • INNOVATION • RESILIENCE

End to End Approach

Facilitator

Knowledge Integration

From Cutting-Edge Science to Local Actions: Taking End to End Approach



Data Integration and Analysis System : Promoting Knowledge Integration

Capacity Building and Education: Fostering Facilitator

伝統 革新 強靭性

TRADITION • INNOVATION • RESILIENCE

Thank you!

شكرًا لك

谢谢

Gracias!

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ありがとう!