Dam Upgrading to be fit for future challenges

Increasing Climate Resilience and Sustainability, and contributing to Energy Transition

Tetsuya SUMI

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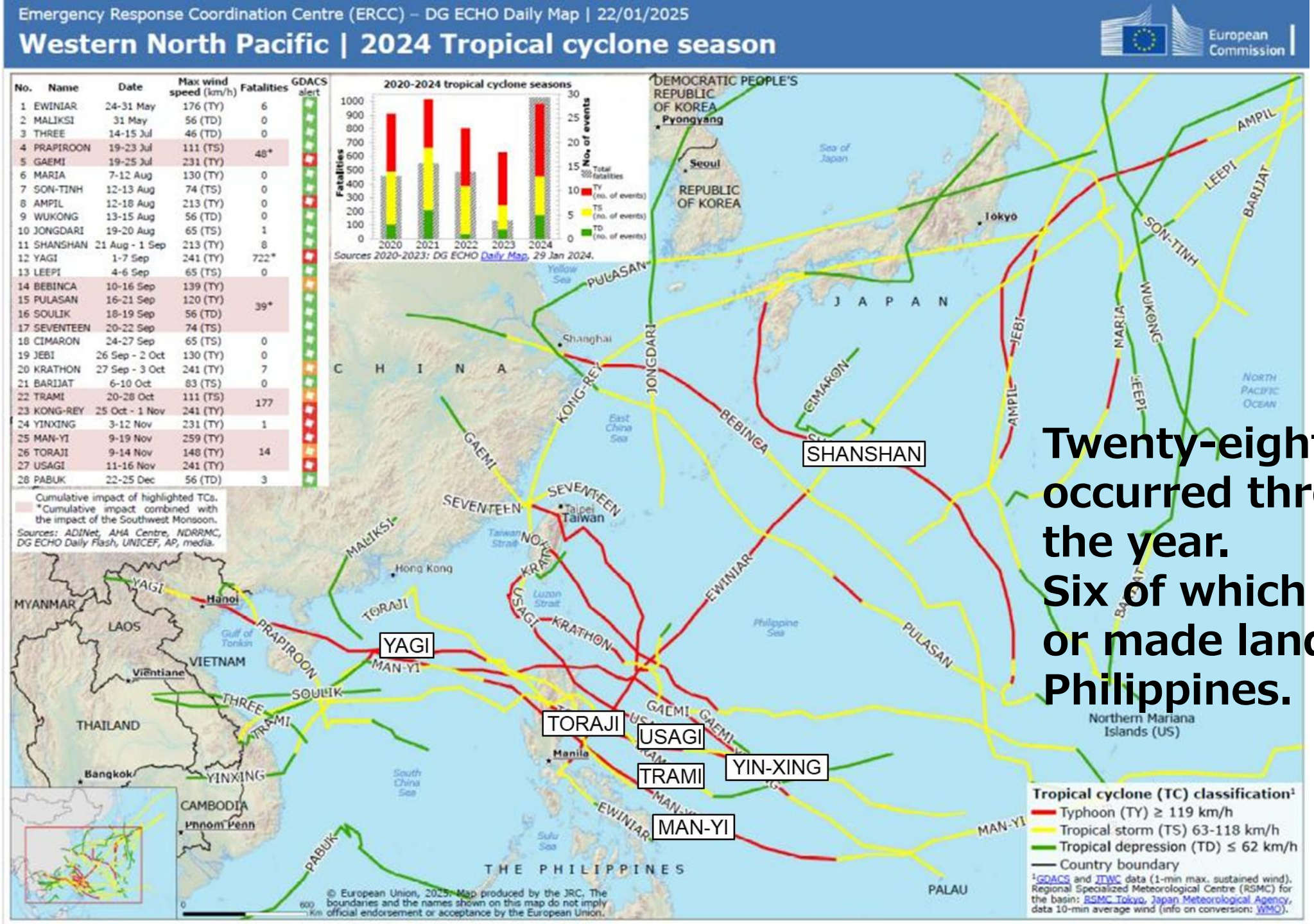
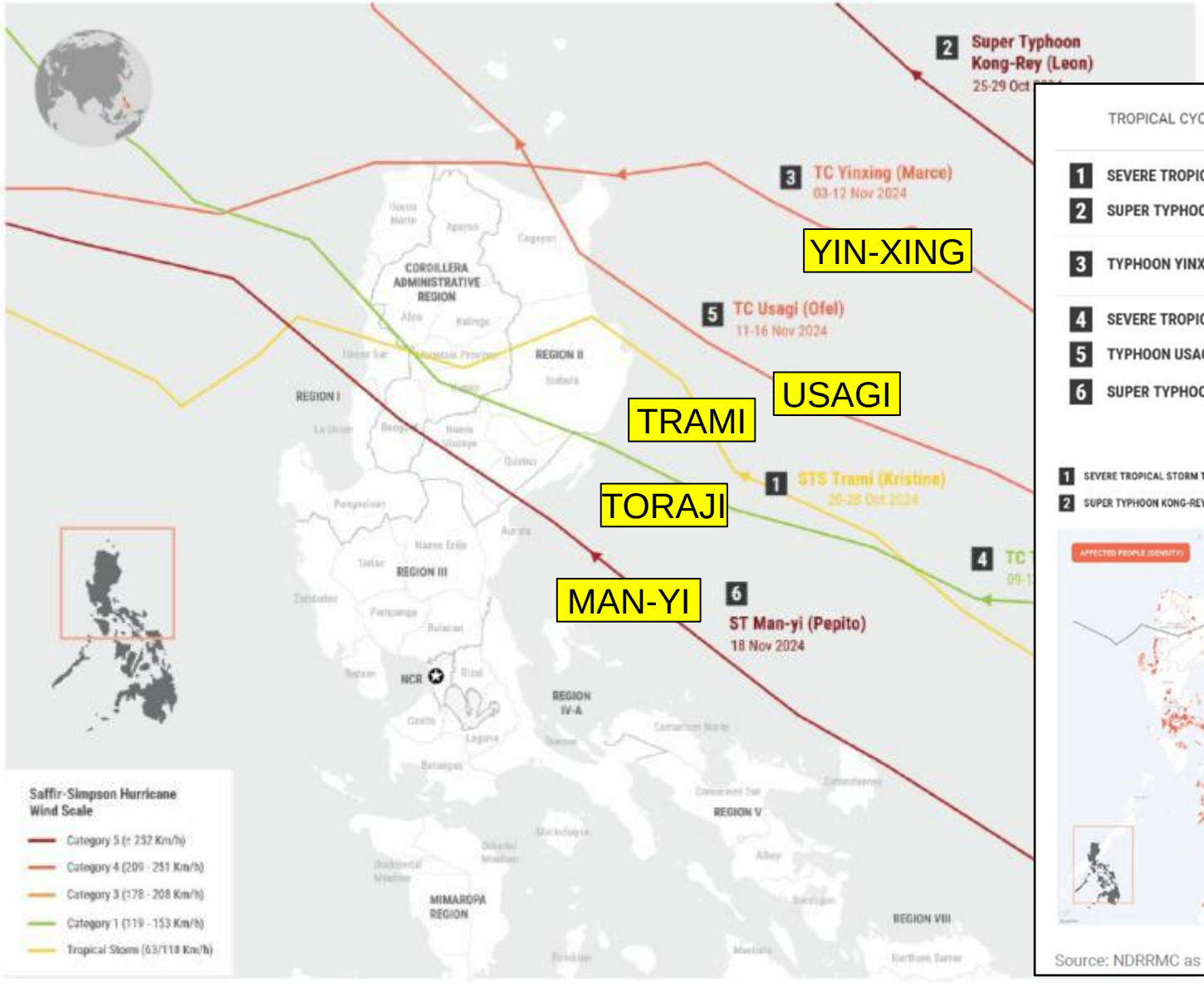
Disaster Prevention Research Institute, Kyoto University
Vice President, International Commission on Large Dams (ICOLD)
Leader, WP4 (Disaster Prevention and Mitigation)
Japan-ASEAN Science, Technology and Innovation Platform (JASTIP)



No.	Name	Date	Max wind speed (km/h)	Fatalities	GDACS alert
1	EWINIAR	24-31 May	176 (TY)	6	
2	MALIKSI	31 May	56 (TD)	0	
3	THREE	14-15 Jul	46 (TD)	0	
4	PRAPIROON	19-23 Jul	111 (TS)	48*	
5	GAEMI	19-25 Jul	231 (TY)		
6	MARIA	7-12 Aug	130 (TY)	0	
7	SON-TINH	12-13 Aug	74 (TS)	0	
8	AMPIL	12-18 Aug	213 (TY)	0	
9	WUKONG	13-15 Aug	56 (TD)	0	
10	JONGDARI	19-20 Aug	65 (TS)	1	
11	SHANSHAN	21 Aug - 1 Sep	213 (TY)	8	
12	YAGI	1-7 Sep	241 (TY)	722*	
13	LEEPI	4-6 Sep	65 (TS)	0	
14	BEBINCA	10-16 Sep	139 (TY)	39*	
15	PULASAN	16-21 Sep	120 (TY)		
16	SOULIK	18-19 Sep	56 (TD)		
17	SEVENTEEN	20-22 Sep	74 (TS)		
18	CIMARON	24-27 Sep	65 (TS)	0	
19	JEBI	26 Sep - 2 Oct	130 (TY)	0	
20	KRATHON	27 Sep - 3 Oct	241 (TY)	7	
21	BARIJAT	6-10 Oct	83 (TS)	0	
22	TRAMI	20-28 Oct	111 (TS)	177	
23	KONG-REY	25 Oct - 1 Nov	241 (TY)		
24	YINXING	3-12 Nov	231 (TY)	1	
25	MAN-YI	9-19 Nov	259 (TY)	14	
26	TORAJI	9-14 Nov	148 (TY)		
27	USAGI	11-16 Nov	241 (TY)		
28	PABUK	22-25 Dec	56 (TD)	3	

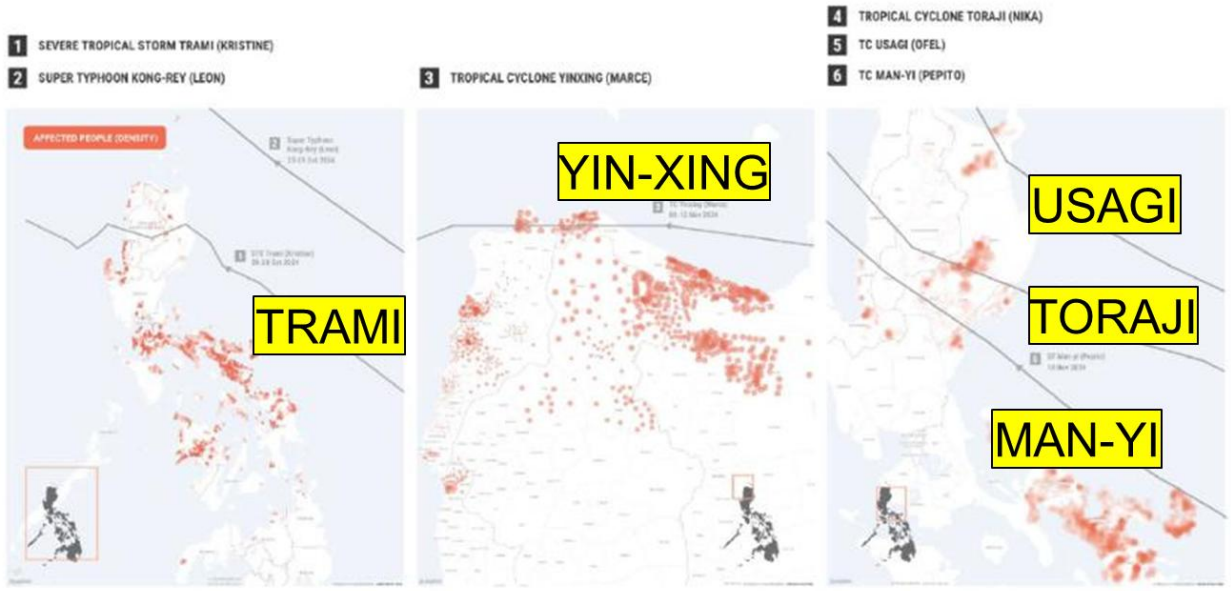
Twenty-eight typhoons occurred throughout the year.
Six of which approached or made landfall in the Philippines.

Source: European Commission



People Affected | People Displaced | Damaged Houses | Destroyed Houses

TROPICAL CYCLONES	PEOPLE AFFECTED	PEOPLE DISPLACED	DAMAGED HOUSES	DESTROYED HOUSES
1 SEVERE TROPICAL STORM TRAMI (KRISTINE) 2 SUPER TYPHOON KONG-REY (LEON)	9.6M	617K	191K	17K
3 TYPHOON YINXING (MARCE)	387.5K	260	28K	1K
4 SEVERE TROPICAL STORM TORAJI (NIKA) 5 TYPHOON USAGI (OFEL) 6 SUPER TYPHOON MAN-YI (PEPITO)	4.3M	124K	62K	17K

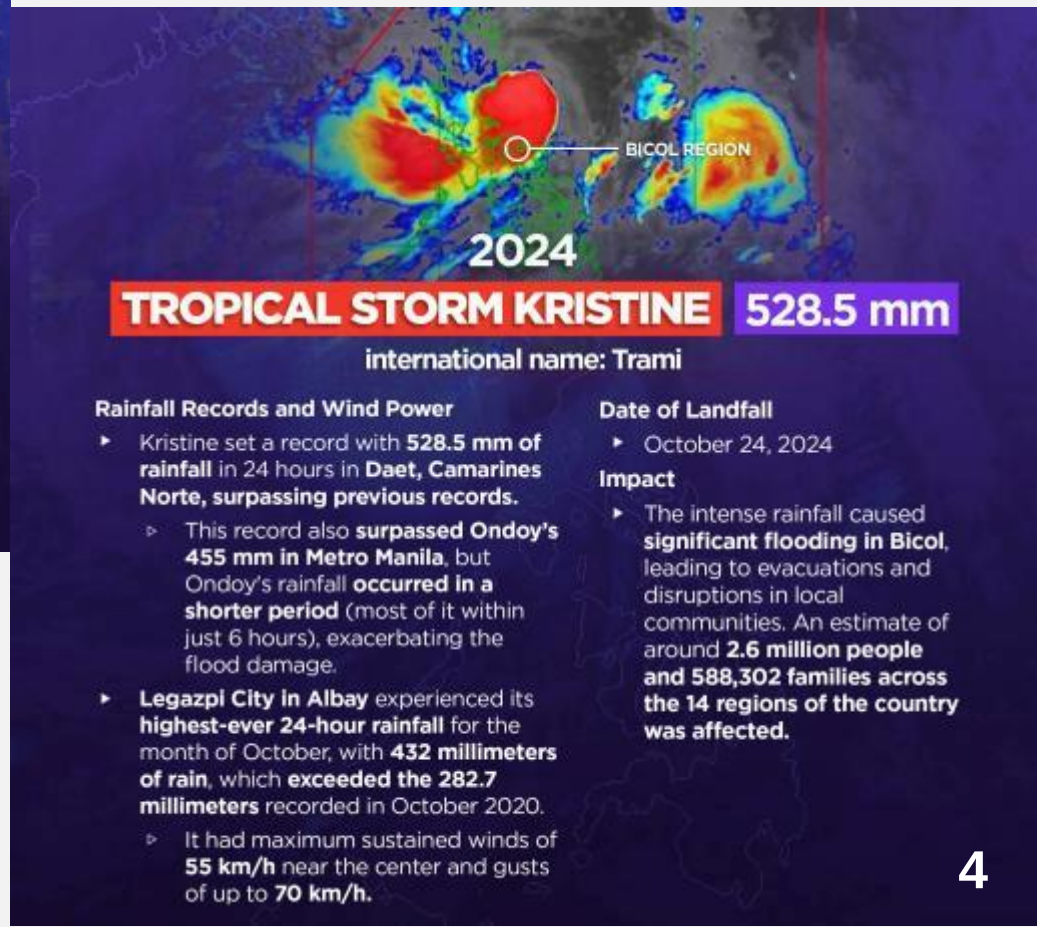


Source: NDRRMC as of 27 November 2024

Source: OCHA

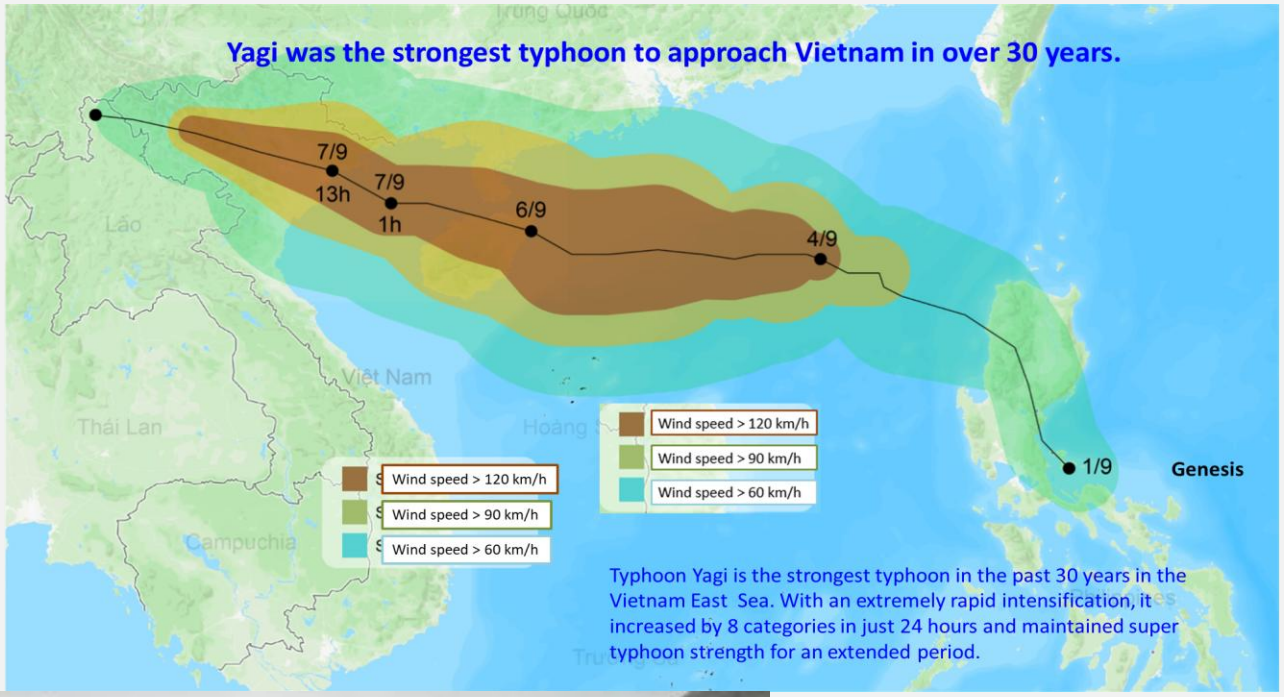
Comparing Trami's Record to PH's Strongest Typhoon

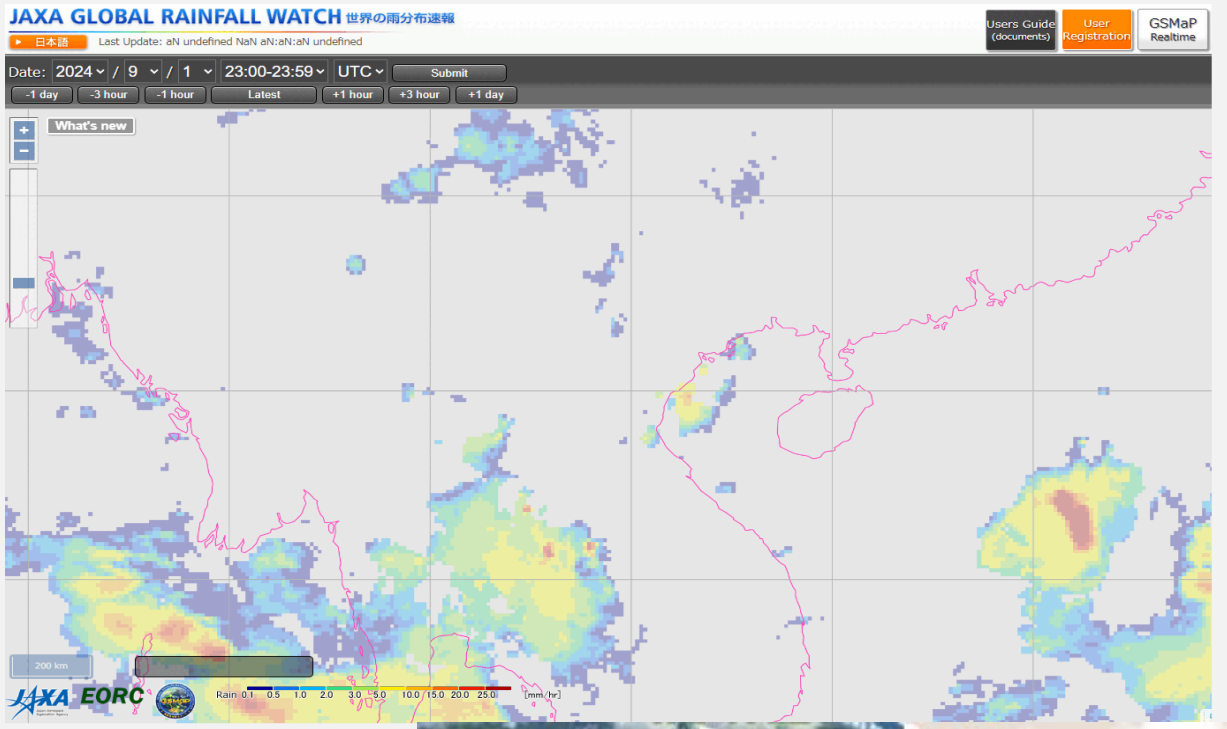
(Assortedge, Oct.26, 2024)
(Photo source: DOST-PAGASA)

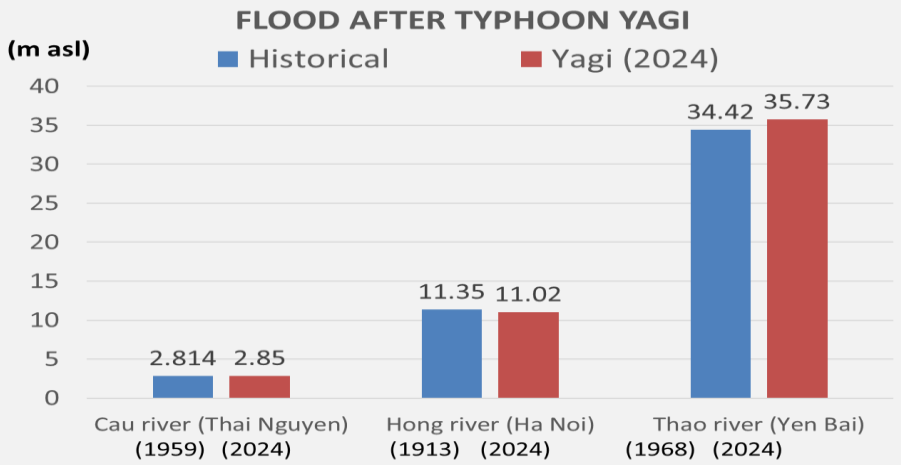


Kristine's (Trami) torrential 528.5 millimeters of rain in Daet, Camarines Norte, has surpassed records and challenges even the historic rains brought by Typhoons Ondoy and Yolanda.

Super Typhoon Yagi attached to Vietnam, Sep.1 to 8, 2024



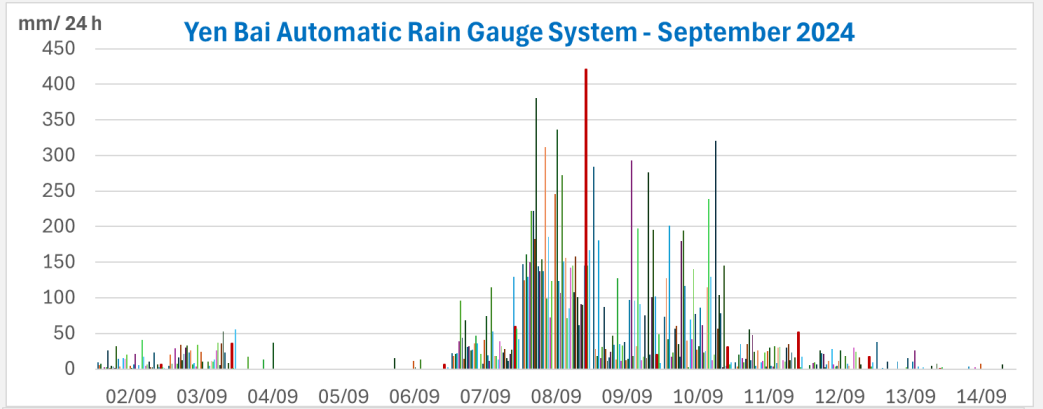


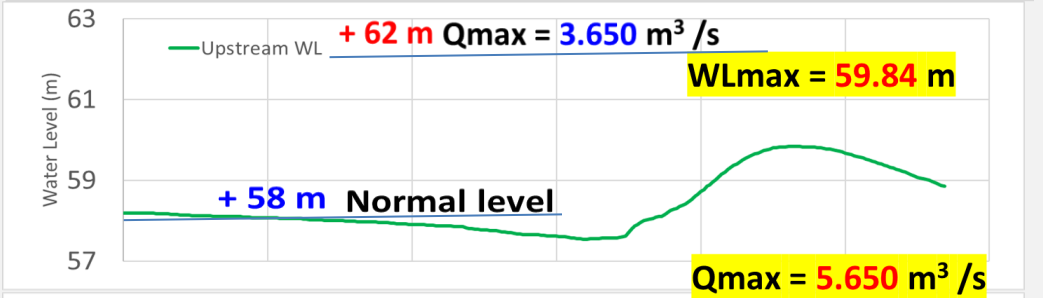


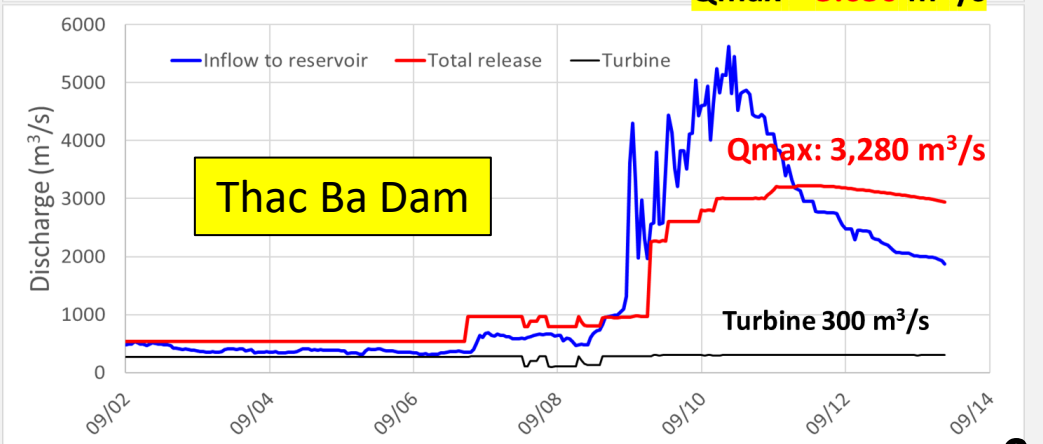
Flood control discharge at Thac Ba Dam, Sep.9 to 12, 2024

Thac Ba Dam

Hoa Binh Dam







Japan-ASEAN Science, Technology and Innovation Platform (JASTIP) , WP4 (Disaster Prevention and Mitigation)

(2020-2025)




Ali Bin Selamat, Khamarrul Abd Razak, Faizah bt Che Ros, Shohei Matsuura, MJIIT/UTM


Tetsuya Sumi and Takahiro Sayama, Kyoto University

The 2nd Phase WP4 (Disaster Prevention and Risk Reduction)

	Research Topics
Malaysia	Storm, Flood, Landslide, Debris Flow, WQ, Community Based-DRR, ICT for DRR, DRR in World Heritage sites
Vietnam	Mekong River (Sediment, Salt water intrusion, Bank erosion), River Basin Management (Flood, Water Resources and Sediment, Coastal erosion)
Indonesia	Peatland Flood, Sediment, Landslide, Transboundary Air Pollution (Haze)
The Philippines	River Basin Management (Flood, Water Resources and Sediment), Pre-disaster Recovery Planning,
Thailand	Liquefaction by earthquake, Mekong River
Myanmar	Rainfall and Evaporation Observation at Dams, Flood, Dam Safety, Earthquake
Cambodia	Mekong River, Water resources management in Tonle Sap
Lao PDR	Mekong River
Brunei	Transboundary Air Pollution (Haze)

Nguyen Canh Thai

Pham Hong Nga

Apip

Orlando F. Balderama

Norio Maki

Sameh Kantoush

Ryosuke Uzuoka

Tetsuo Tobita

Kyohei Ueda

Kenji Tanaka

Key outcome of WP4 in the 2nd Phase of JASTIP

Networking among ASEAN and Japan

Create research network group among ASEAN countries

- MJIIT(Malaysia), Thuy Loi(Vietnam), BRIN(Indonesia), ISU(The Philippines) etc.
- The International Organization on Climate Change Adaptation and Disaster Risk Reduction Management Inc. (IO-CCA-DRRM)

Knowledge Base on common DRR

Sharing common disaster management topics under changing climate and SDGs

- River Basin Management (Flood, Water Resources and Sediment)

Collaboration on Transboundary Issues

Starting collaboration on transboundary issues

- Transboundary river issues of the Mekong River
- Peatland fires and Haze, Network with Indonesia, Malaysia, Thailand and other countries with JASTP-NET research collaborations

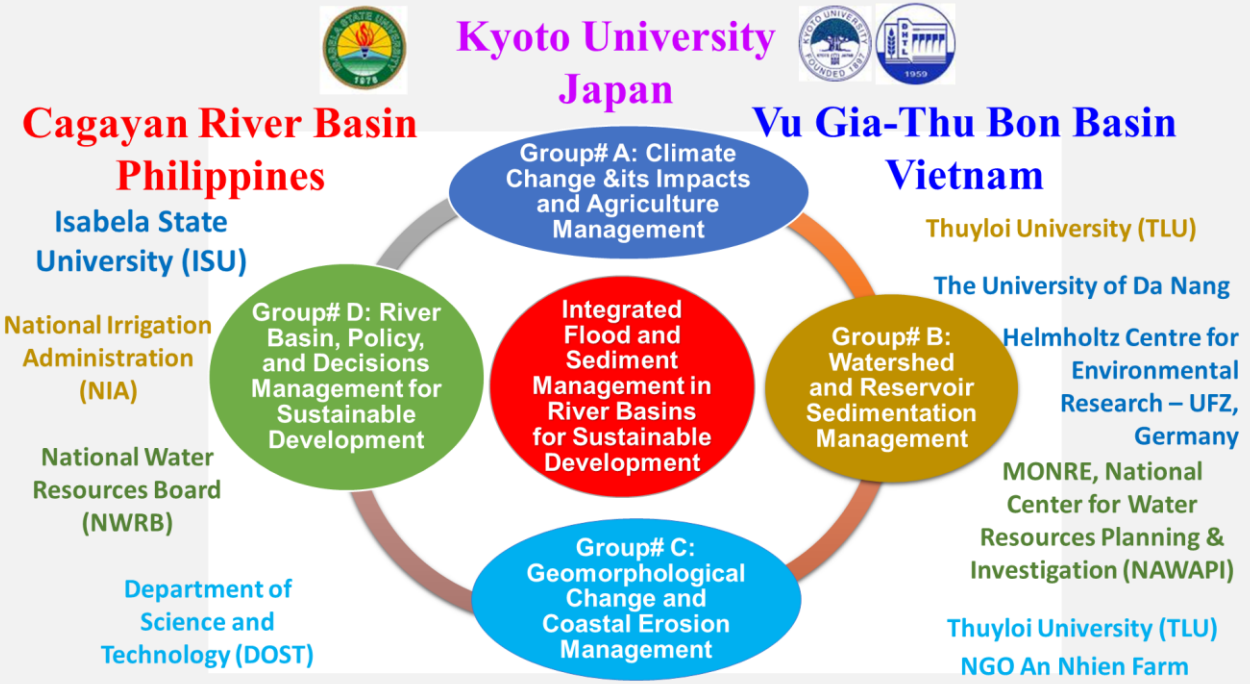
Human Resources Development

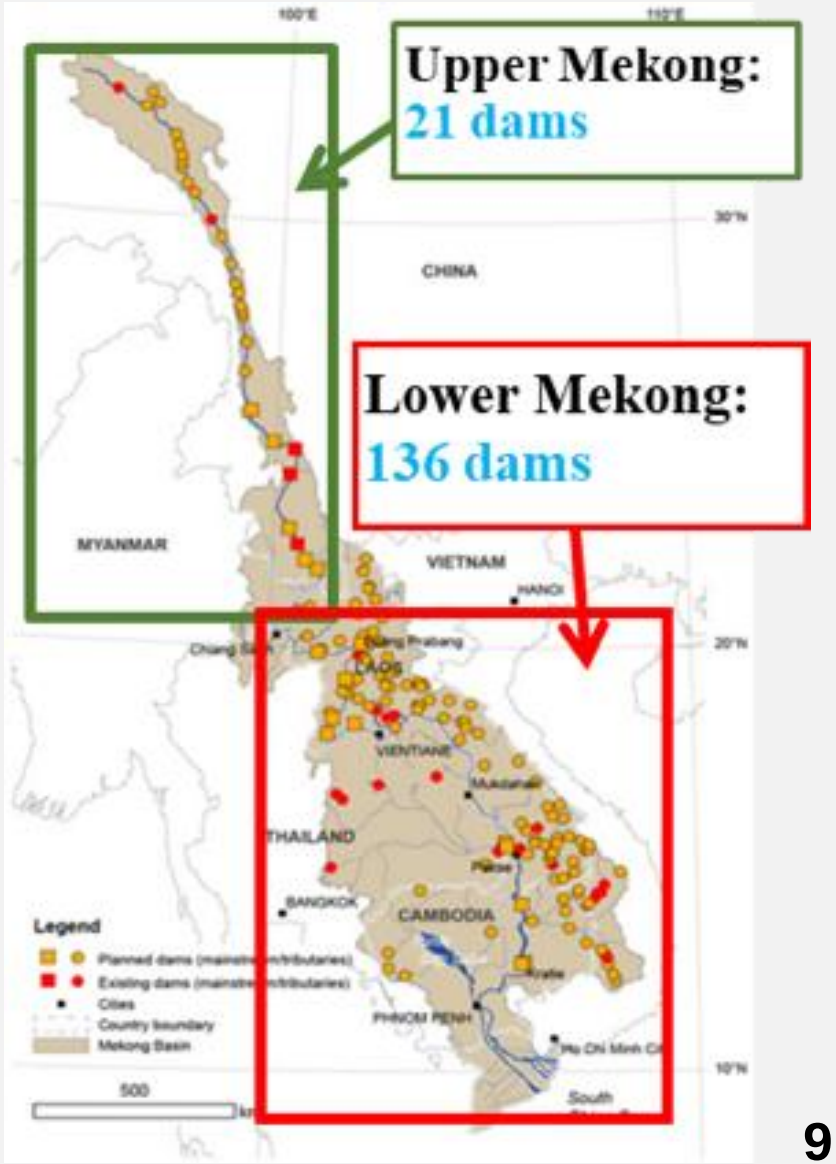
Bridging talented younger professionals to work together among ASEAN and Japan

- Master of Disaster Management (MDRM)" course at MJIIT-DPPC, Japan Attachment
- Ph.D and Master students in KU, UNESCO-IHP TCs under WENDI

Two research pillars
WP4 (Disaster Risk Prevention and Reduction)

1. **Transboundary issues:**
   - **Mekong River (Flow and Sediment Regime Change)**
     Lao PDR, Cambodia and Vietnam
2. **Common issues in ASEAN countries:**
   - **River Basin Management (Flood, Water Resources and Sediment) : The Philippines and Vietnam**



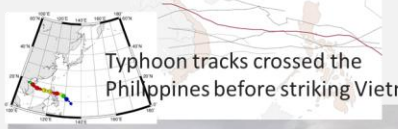


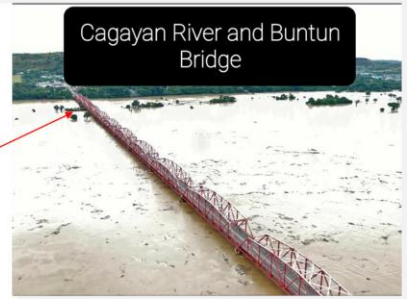
Urgent Post-Flood Joint Research after Typhoon Ulysses 2020, JST (J-RAPID)- DOST(PCIEERD)

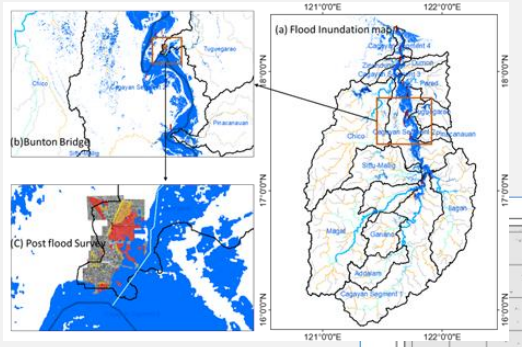
- KU-DPRI: Tetsuya Sumi, Sameh A. Kantoush, Mohamed Saber / JST, JICA, MLIT, JWA
- Isabela State University: Orlando Balderama
- NIA: Carlo Ablan/ PAGASA, DPWH

Flood and sediment disasters in Cagayan River Basin Due to Typhoon (Vamco) smashed Luzon Island on 11-12 Nov. 2020

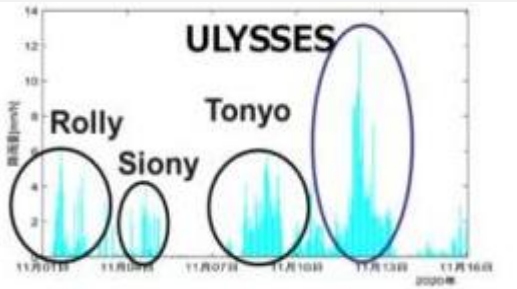
VAMCO/ ULYSSES

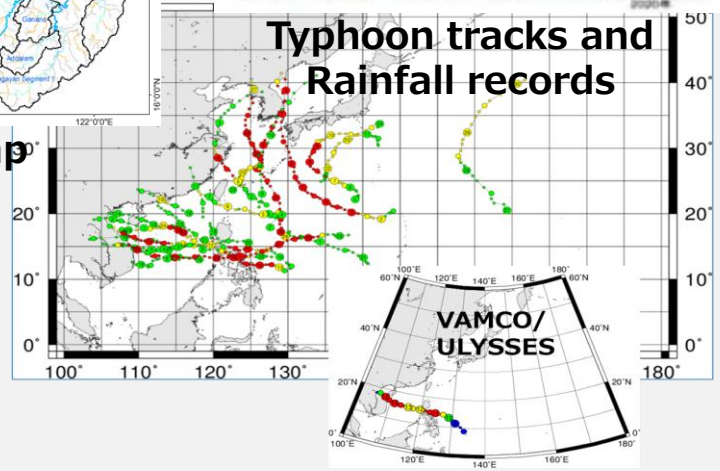






Inundation map





The Magat dam 13th of Nov. 2020

Background and Research Objectives

Typhoon Ulysses attacked the Philippines in 2020 which caused severe flood damages.

Assessing the impacts of successive typhoons specially during Autumn season (last chance for typhoons) on flood and drought risks.

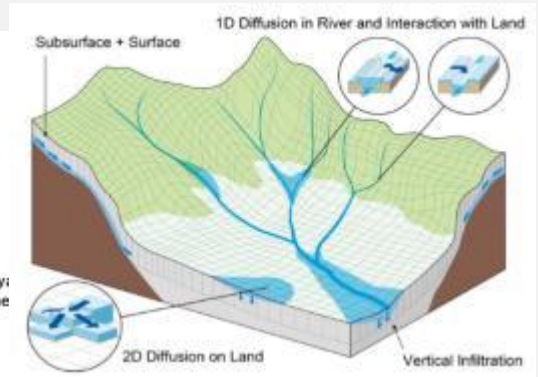
Upgrading/proposing an integrated measures and enhanced strategy for disaster risk reduction of flood and drought risks in the river basin scales.

Problem statement: Limited Long-term Rainfall Prediction data, Unreliable Rainfall-Runoff Model, Lack of reservoir sedimentation data, Missing of proper coordination among stakeholders (PAGASA, NIA, DPWH and others)

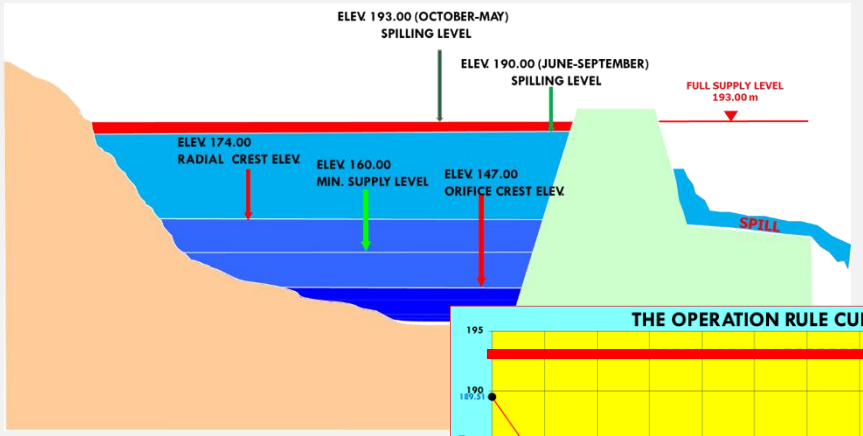
Urgent Post-Flood Joint Research after Typhoon Ulysses 2020, JST (J-RAPID)- DOST(PCIEERD)

Key Topics:

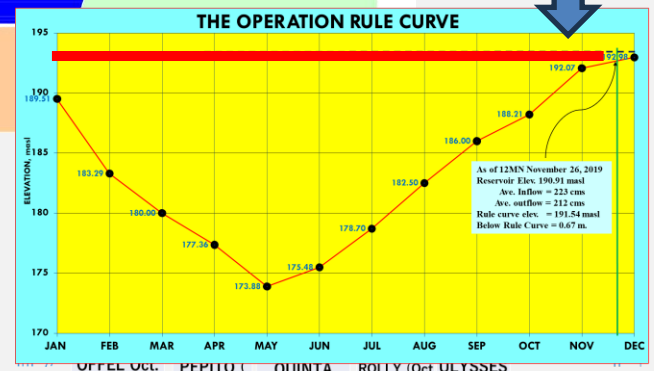
1. Missing Accurate Rainfall Runoff Model
2. Conflict on Seasonal Reservoir Operation Rule
3. Missing Long-Term Rainfall Forecasts
4. Reservoir Storage Loss by Sedimentation

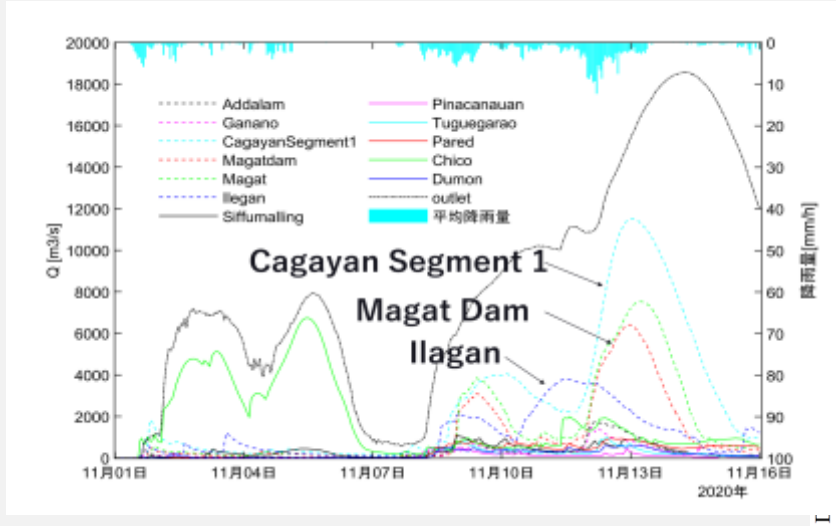


Rainfall Runoff Inundation Model(RRI)

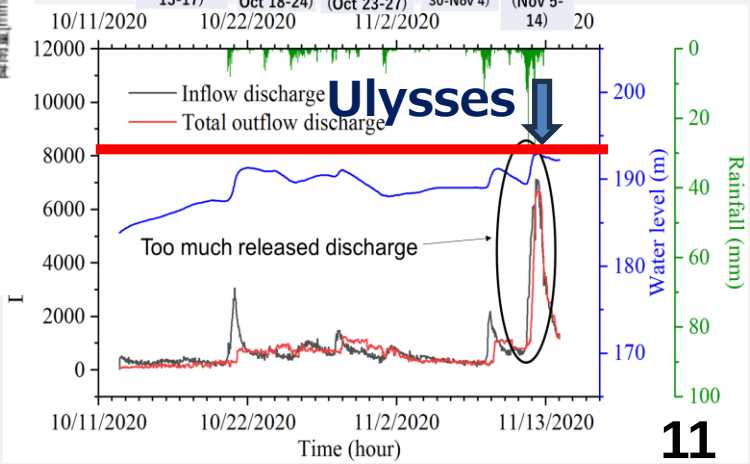


Ulysses





Detect each catchment contribution and timing

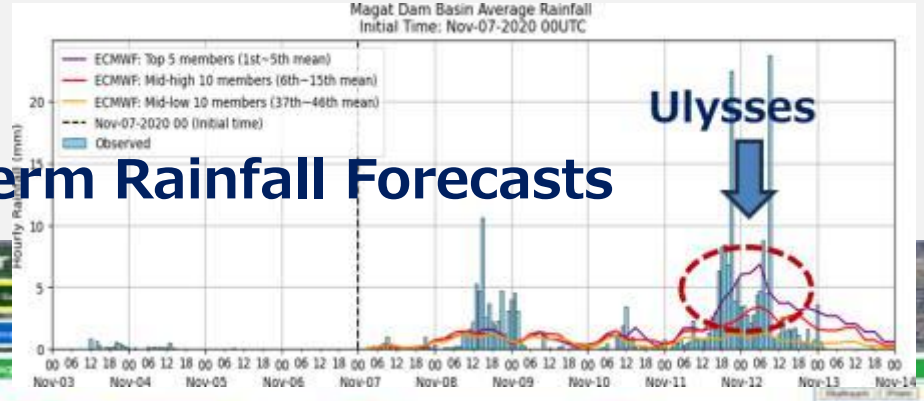


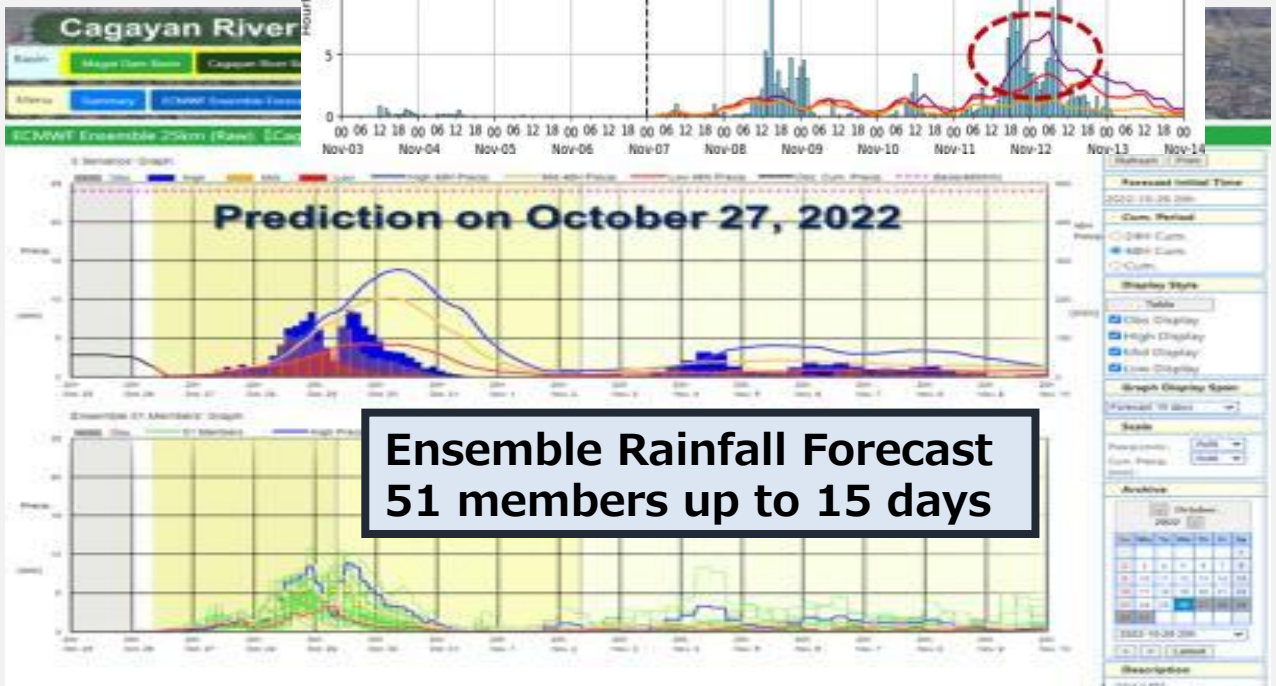
Optimization of Magat Dam Operation for Flood Risk Management in Cagayan River Basin in the Philippines

Research Objectives:

Assessing flood, drought risks and extreme climate events in the Cagayan River Basin and proposing flood mitigation measures including optimization of dam operation rules and flood control dam in other tributaries sub-basin.

Long-Term Rainfall Forecasts

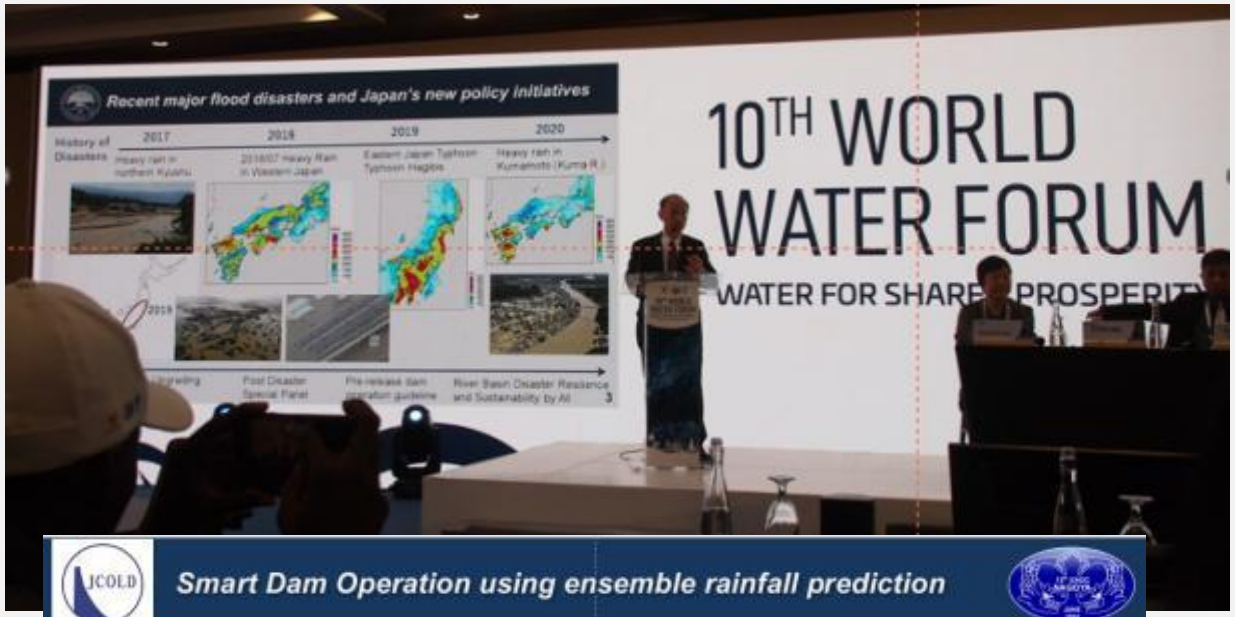


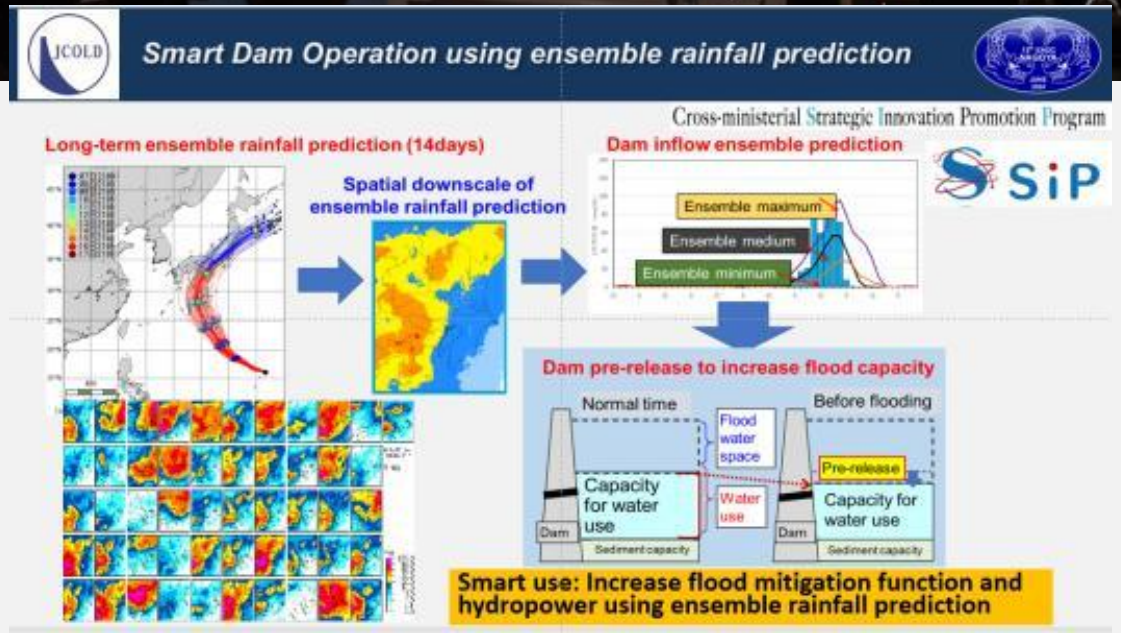


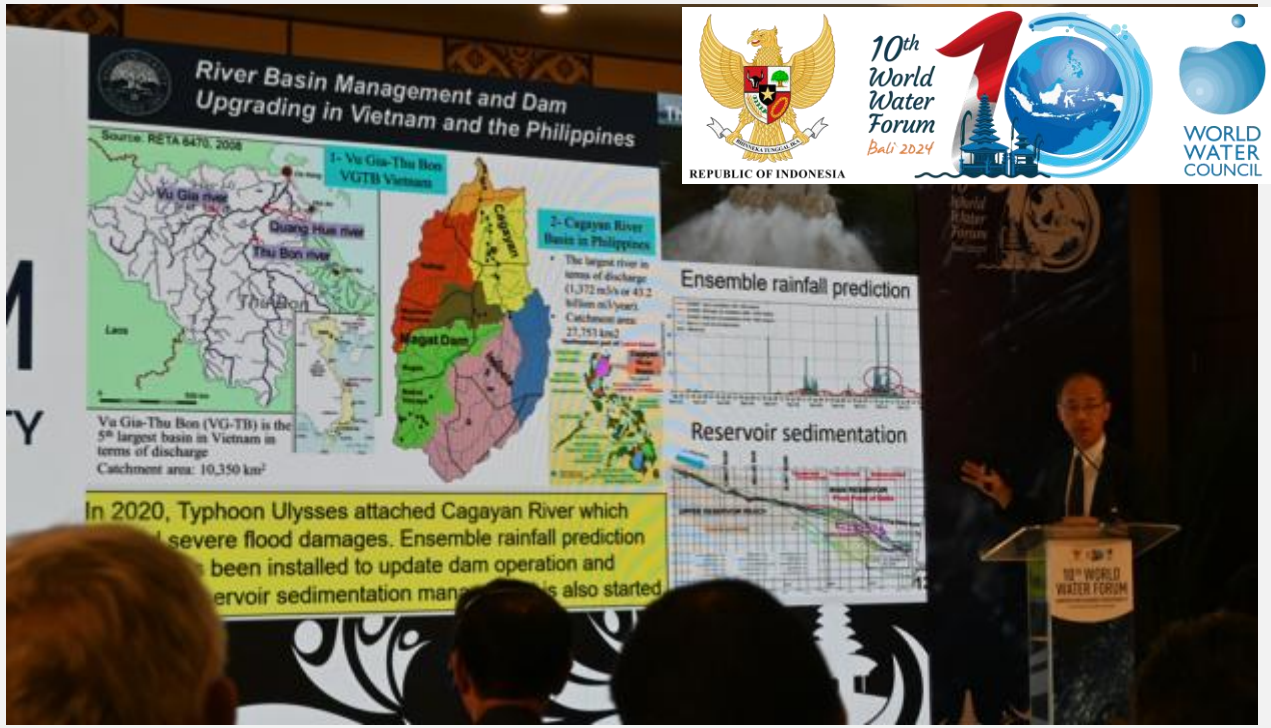
Key Outcomes:

- ✓Developed ensemble rainfall prediction, and Decision Support System (DSS) effective dam operation
- ✓Training Workshop on "Flow and Sediment Transport Modelling in River Basins using TELEMAC 2D and 3D Numerical, February 2022
- ✓Stakeholders Forum on Advances in Technological and Institutional Options for Integrated Watershed Management in River Basins, January, 2022
- ✓**International Association on Climate Change Adaptation and Disaster Risk Reduction Management (IO-CCA-DRMM)**

Reporting at The 10th World Water Forum in Bali, Indonesia, 2024







Two report presentations:

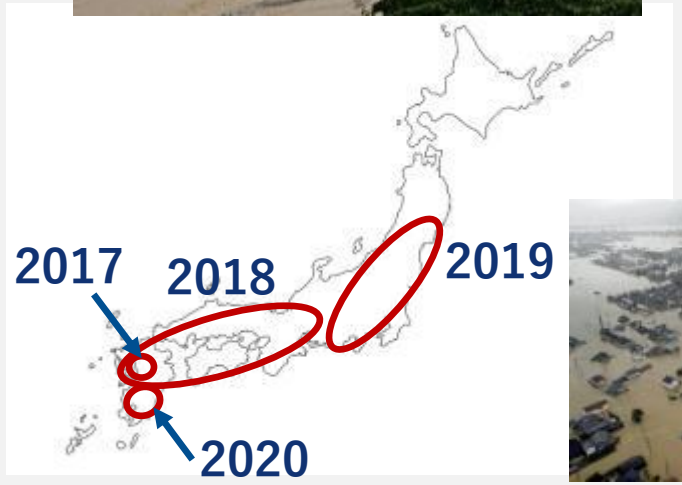
- Integrated Reservoir Operation for Flood, Sediment and Hydropower Management using Ensemble Rainfall Prediction
- Dam upgrading and reservoir sedimentation management for flood mitigation, and reservoir and river basin sustainability

Recent major flood disasters and Japan's new policy initiatives

History of Disasters

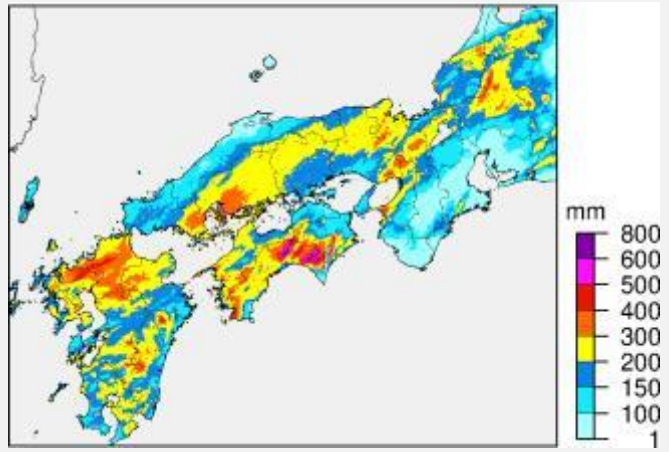
2017

Heavy rain in northern Kyushu



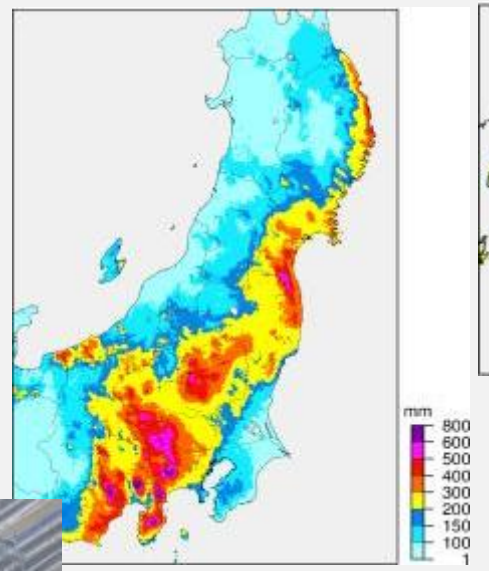
2018

2018/07 Heavy Rain in Western Japan



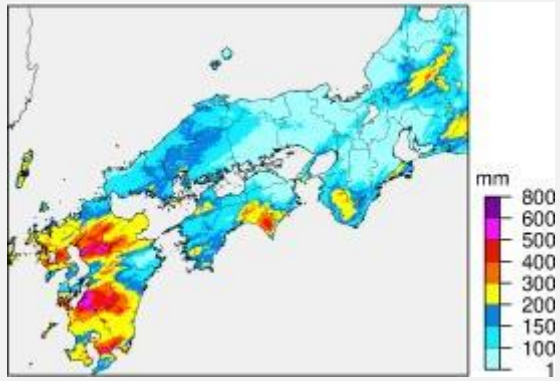
2019

Eastern Japan Typhoon Typhoon Hagibis



2020

Heavy rain in Kumamoto (Kuma R.)



Policy Initiatives

Dam Upgrading Vision

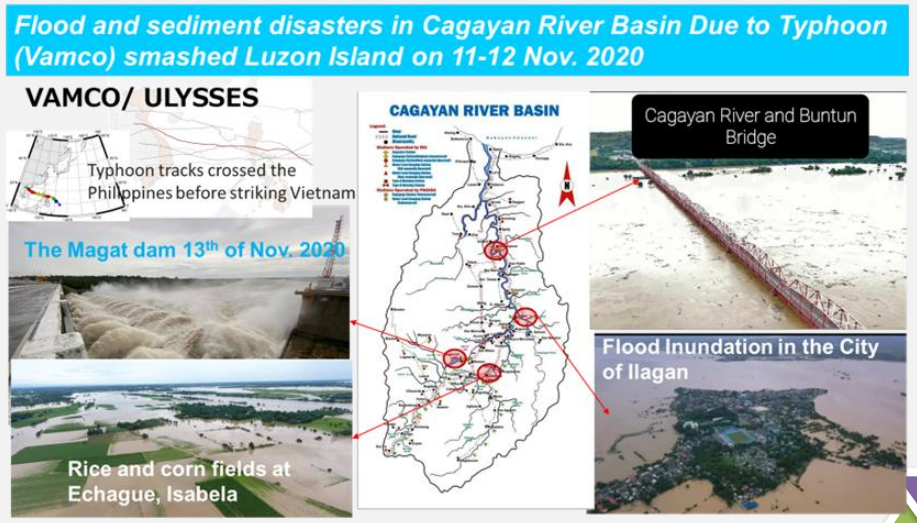
Post Disaster Special Panel

Pre-release dam operation guideline

River Basin Disaster Resilience and Sustainability by All

Challenges on Dams in the 21th Century Society

Magat Dam and Cagayan River



Climate Change

Extreme Flood and Drought

Disaster prevention and Mitigation

Carbon Neutrality

Mis-communica-tion on Dam Operation and Function

Aging Dams

Reservoir Sustainability

Hiyoshi Dam and Katsura River

Japan's New Policy on Water-related Disaster Risk Reduction (MLIT, 2020)

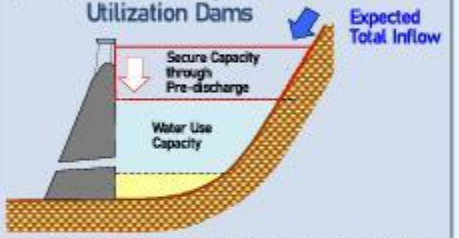
IMAGE OF RIVER BASIN DISASTER RESILIENCE AND SUSTAINABILITY BY ALL

1) Examples of Flood Prevention

(Ex. 1) Development of Levees

Heightening and strengthening of levees

(Ex. 2) Pre-Discharge from Water Utilization Dams



Discharge some of the service water capacity of existing dams, such as water utilization dams, in advance of floods, according to inflow expectations

(Ex. 3) Development of Storage Facilities

Develop rainwater storage facilities to reduce inflow into rivers and downstream areas

1) Flood Prevention

Catchments

- **Improve rainwater storage functions** <P / M / E / R>
  Improve rainwater storage facilities and effectively use agricultural reservoirs for flood control

River Areas

- **Store flowing water** <N / P / M / W>
  Construction, upgrades, effective use of dams, and pre-discharge in water utilization dams for flood control
  <N / P / M>
  Upgrade retarding function integrally with land use
- **Ensure and improve the discharge capacity of river channels** <N / P / M>
  Channel excavation, setting back levees, and improvement of erosion control dams and rainwater drain facilities
- **Reduce overflow** <N / P>
  Strengthen levees to make them last a long time even when overlapping

2) Exposure Reduction

Floodplains

- **Guide residents to lower risk areas / Promote safer ways of living** <M / E/ R>
  Consider land use restrictions, encourage relocation, provide flood risk information in real estate transactions, and improve financial tools
- **Localize inundation areas** <N / P / M>
  Install banking structures and utilize existing facilities, which play the role of secondary levees

<>: Expected to be implemented by
N: National Government, P: Prefectures, M: Municipalities, E: Private Enterprises, R: Residents, W: Water Users

3) Disaster Resilience

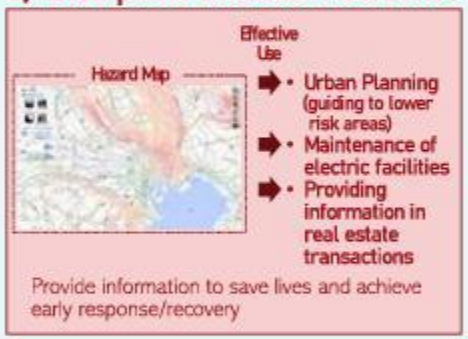
Floodplains

- **Improve risk information on land** <N / P>
  Promote the designation of probable inundation zones so there is sufficient area covered by risk information
- **Reinforce evacuation systems** <N / P / M>
  Develop long-term prediction technologies and acquire real-time inundation and breach detection technologies
- **Minimize economic damages** <E / R>
  Prepare anti-inundation measures in factories and buildings and develop BCPs
- **Promote safer ways of living** <E / R>
  Provide flood risk information in real estate transactions and promote anti-inundation preparedness through financial tools
- **Improve technical support systems for affected local governments** <N / E>
  Strengthen TEC-FORCE (Technical Emergency Control Force, managed by MLIT)
- **Eliminate inundation promptly** <N / P / M etc.>
  Improve sluice gates

2) Example of Exposure Reduction

Localize inundation areas through overflow control using ring levees and secondary levees

3) Example of Disaster Resilience



Provide information to save lives and achieve early response/recovery

Cooperation of Every Stakeholder

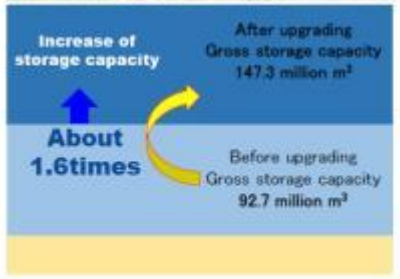
Participants:
- National Government
- Prefectures
- Municipalities
- Private Enterprises
- Residents
- Water Users

(Deciding on project details)

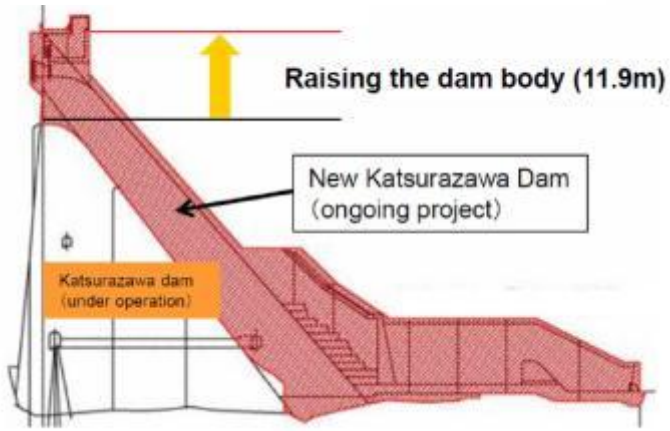
Types of dam upgrading projects in Japan

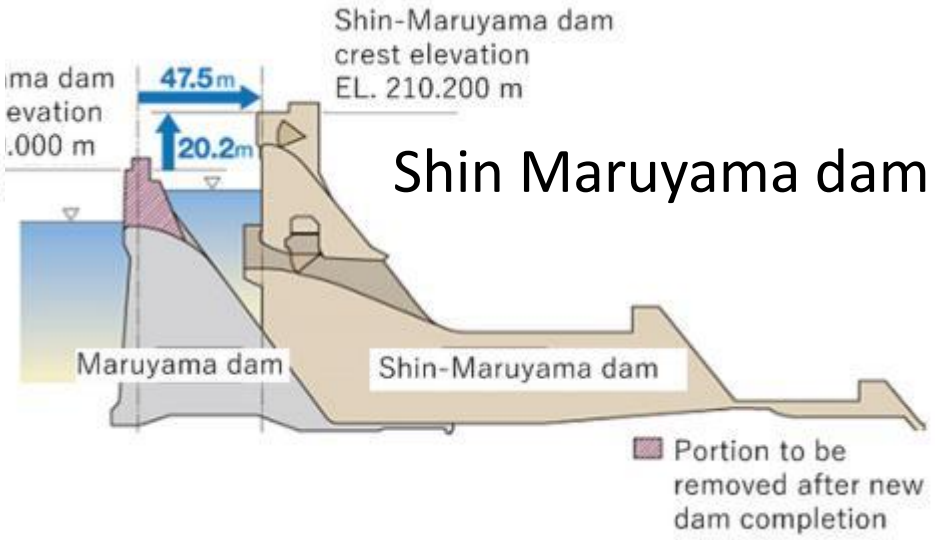
Smart use

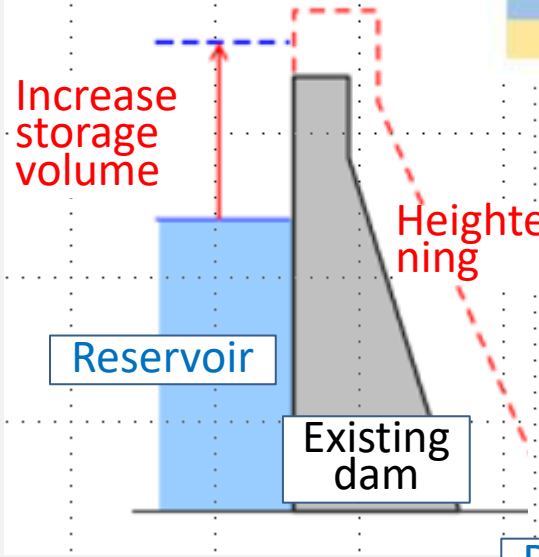
Heightening to increase storage volume



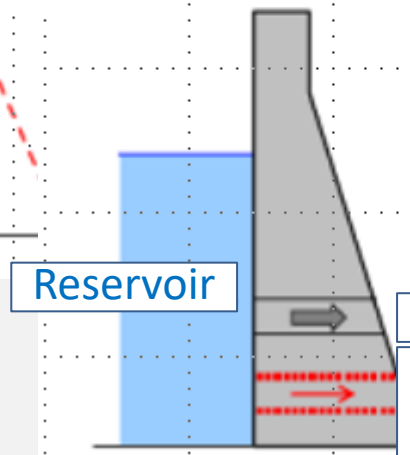
Shin Katsurazawa dam







Install additional bottom outlets to increase discharge capacity



Existing bottom outlet

New bottom outlet
Increase discharge capacity

Tsuruda dam

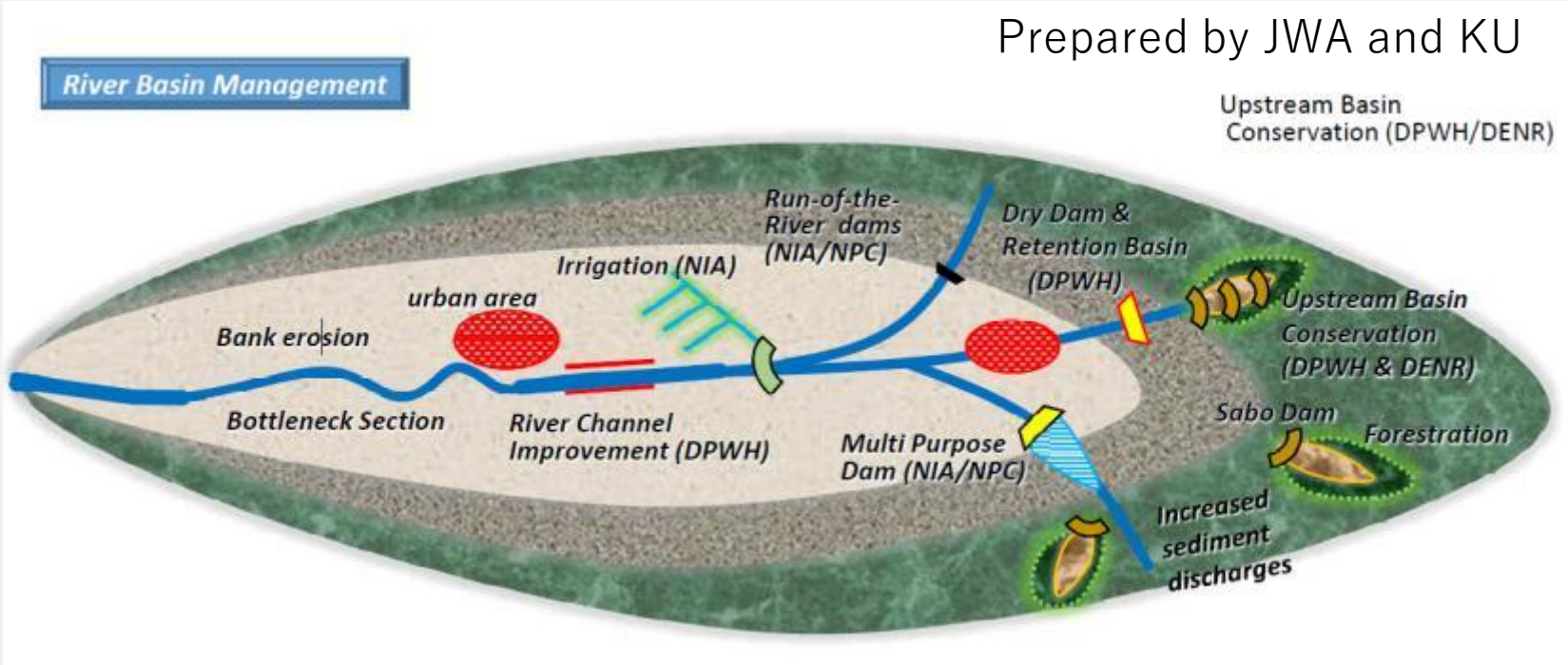
Source: MLIT

Concept of Integrated River Basin Management

1. Optimization of Reservoir Operation based on Rainfall-Runoff Prediction
2. Upgrading Dam Facilities for Flood and Sediment Management
3. Additional Investments for flood and sediment management in the basin scale
   - flood retention dams, sediment check dams, river channel improvement etc.

Stakeholder coordination is essential to implement such comprehensive approach

Prepared by JWA and KU



How to share available information and data ?
How to collaborate among these stakeholders and bridging their tasks ?
How to create common platform to understand current condition and future scenarios?
Who will coordinate discussion and master planning ?

Adopted for the new JST-NEXUS program on Water Security

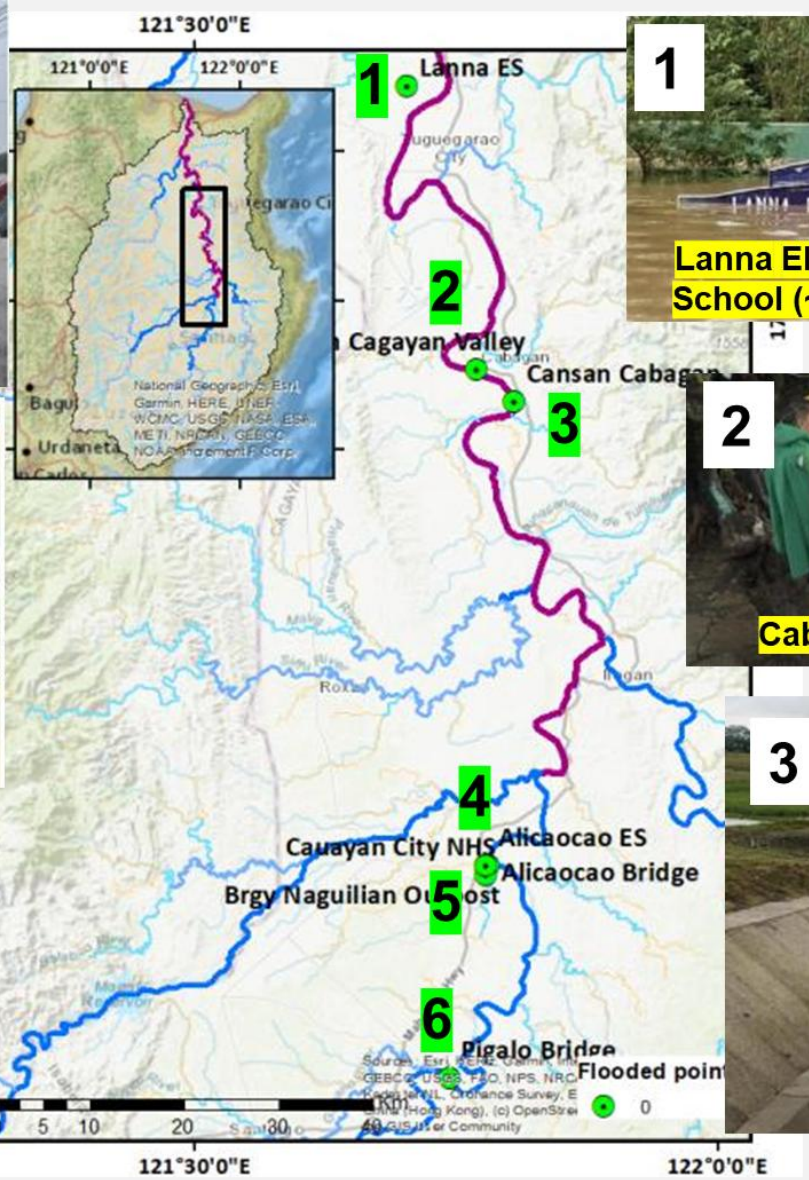
Synergistic Strategies for Sustainable Water Resources and Dam Management under Extreme Climate Variability 3S-WaRM (2025 -2027)

NEXUS-Philippines: Networked Exchange, United Strength for Stronger Partnerships between Japan and ASEAN
Funded by Japan Science and Technology Agency (JST) and Department of Science and Technology (DOST)

Japan-based Principal Investigator
Prof. Sameh Kantoush
(Kyoto University)

Philippines-based Principal Investigator
Prof. Jeoffrey Lloyd Bareng
(Isabela State University)

Recent Flood events in the Cagayan River Basin [Oct. - Dec.2024]

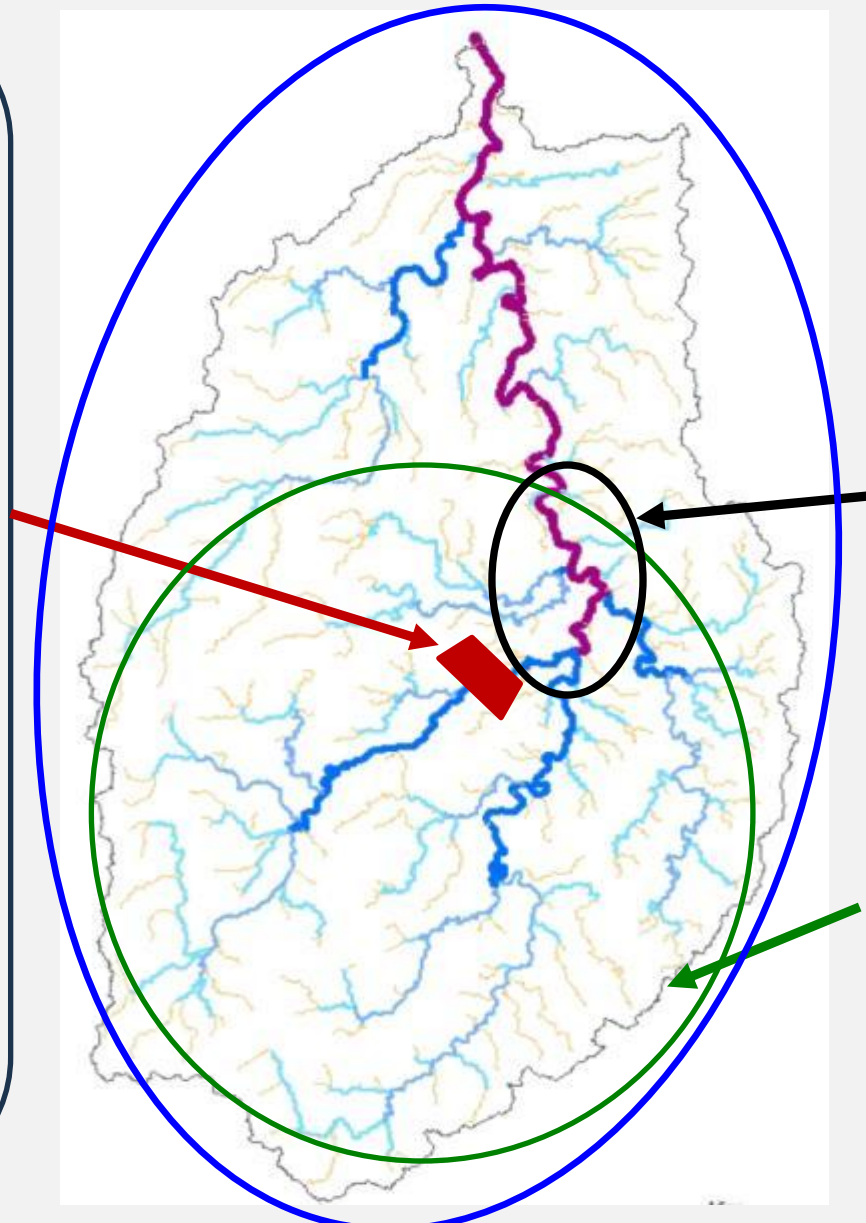


Ongoing Efforts and Future in Cagayan River Basin

The Magat dam

Optimization and Management of dam operation

Sediment management



Water resources management for water and food security, renewable energy

Early Warning system for Flood Risk Reduction

Improve monitoring stations and satellite remote sensing

Rainfall prediction and inflow estimation

Main Research Objectives

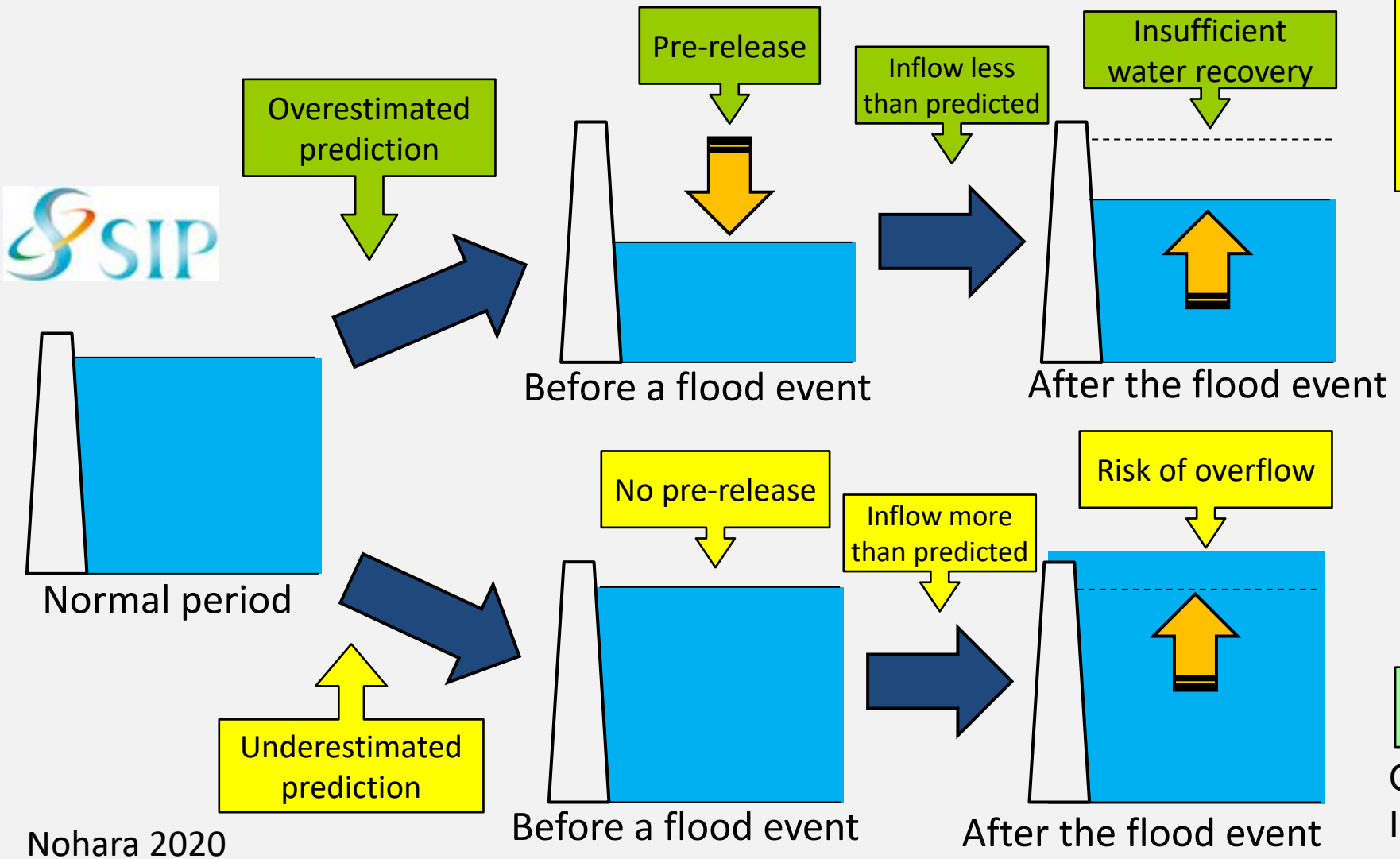
1. **Assessment of water resource management and existing dam operation management under extreme climatic conditions**
2. **Application of cutting-edge tools for dam operations and water resource management**
3. **Optimization of dam/reservoir to reduce the risk of drought and flood impacts.**
4. **Implementation of Integrated Water Resources Management (IWRM) good practices: formulation of water resources guidelines and plans for river basins and communities, stakeholder forum, and capacity development.**

Understanding the spatiotemporal variation in the Magat River basin's water availability, identifying the limiting application scenario of the existing reservoir operation rule, and revising the operation framework to adequately address future supply-demand uncertainty.

Prediction uncertainty on pre-release operation
Conflicts between flood mitigation and water storage

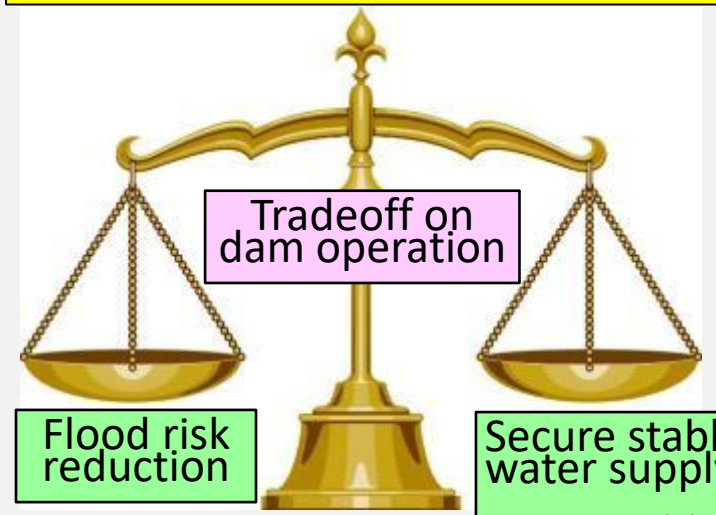
Handling uncertainty contained in the predictions has been issues.

Cross-ministerial Strategic Innovation Promotion Program



Nohara 2020

It is difficult to know suitable amount of preliminary release volume because of rainfall prediction uncertainty.



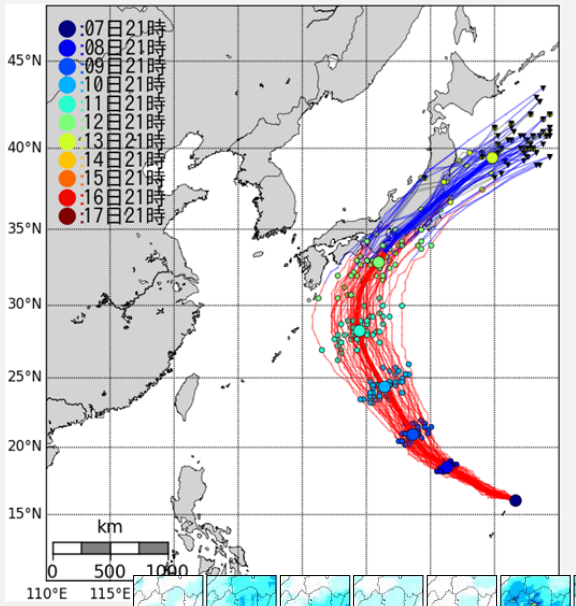
SIP Model

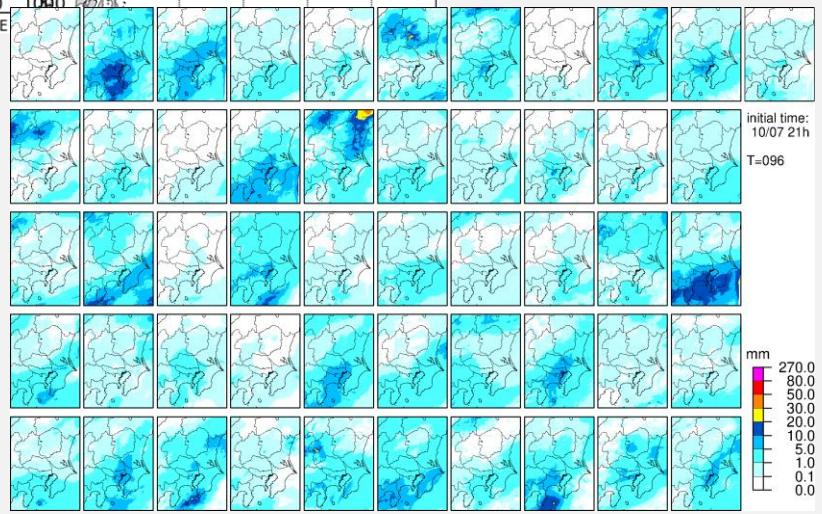
Cross-ministerial Strategic Innovation Promotion Program

SIP Cross-ministerial Strategic Innovation Promotion Program (Decision support system for the Integrated dam operation)

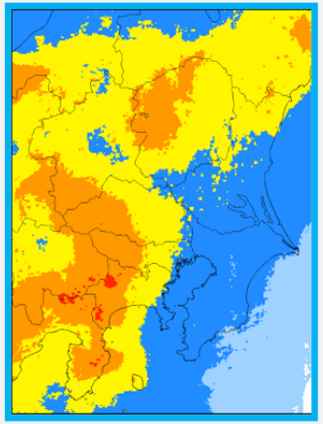
Cross-ministerial Strategic Innovation Promotion Program

Long-term ensemble rainfall prediction (14days)

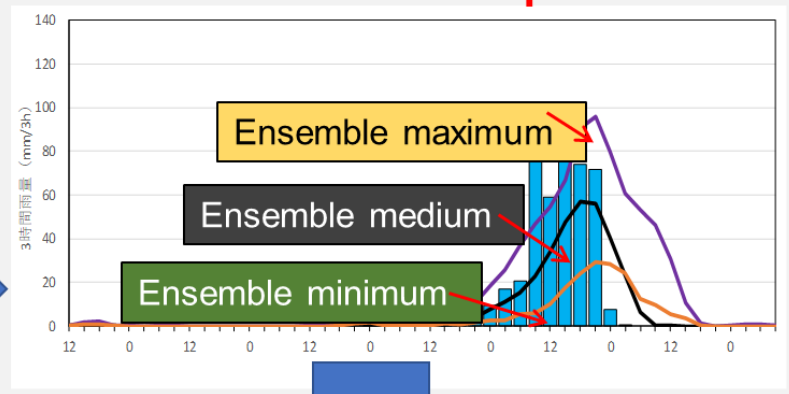




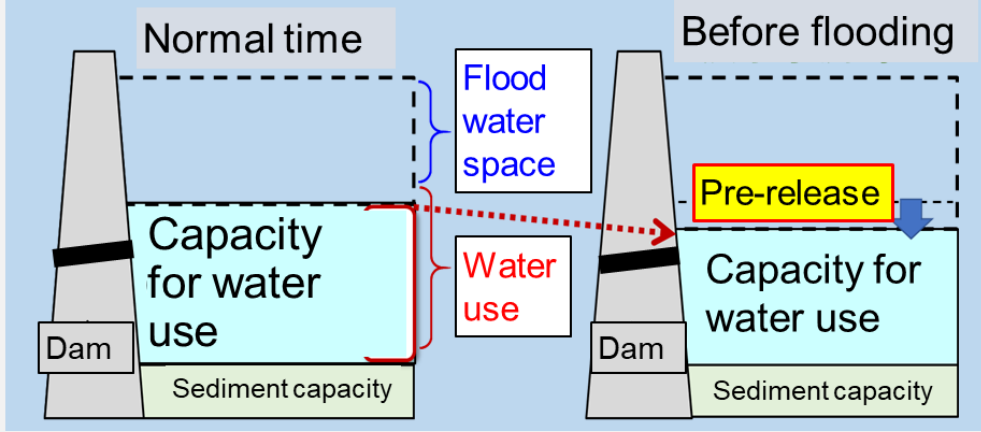
Spatial downscale of ensemble rainfall prediction



Dam inflow ensemble prediction



Dam pre-release to increase flood capacity



Advantages of Long-term rainfall prediction

Cross-ministerial Strategic Innovation Promotion Program

Present GSM Prediction

3-days rainfall predictions

- ✓Max three days prediction
- ✓Single prediction (one member)
- ✓No information on reliability

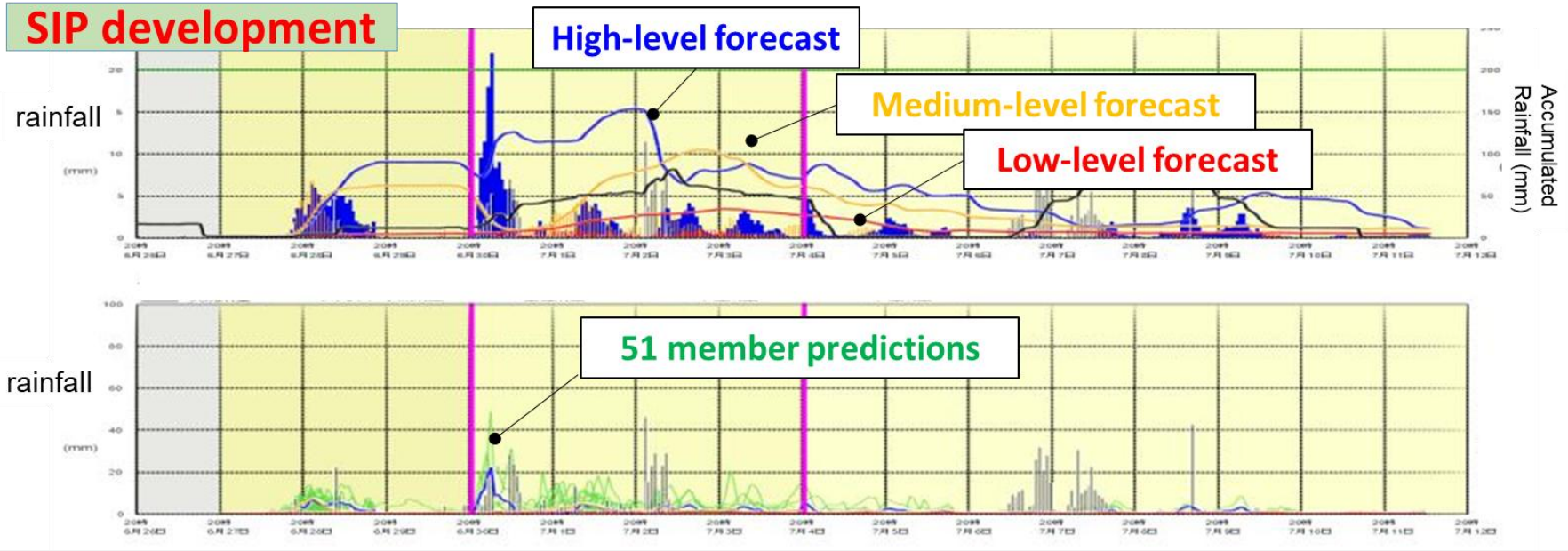
→ **No reliable information to manage dam reservoir**

SIP development → **Reliable information for adaptive operation considering risk information**

- ✓15 days predictions
- ✓51 ensemble members that enable understanding of risks of not recovering water storage and flood risk
- ✓Long-term prediction to prepare for the next flood

15-days ensemble rainfall predictions

SIP development



NEXUS-Philippines Project: Groups, Tasks, and Outcomes

1 Water Resources Management

- **Water supply**
- **Agricultural uses**
- **Economic**
- **Planning**

2 Dam optimization under climate change conditions

- **Advanced monitoring**

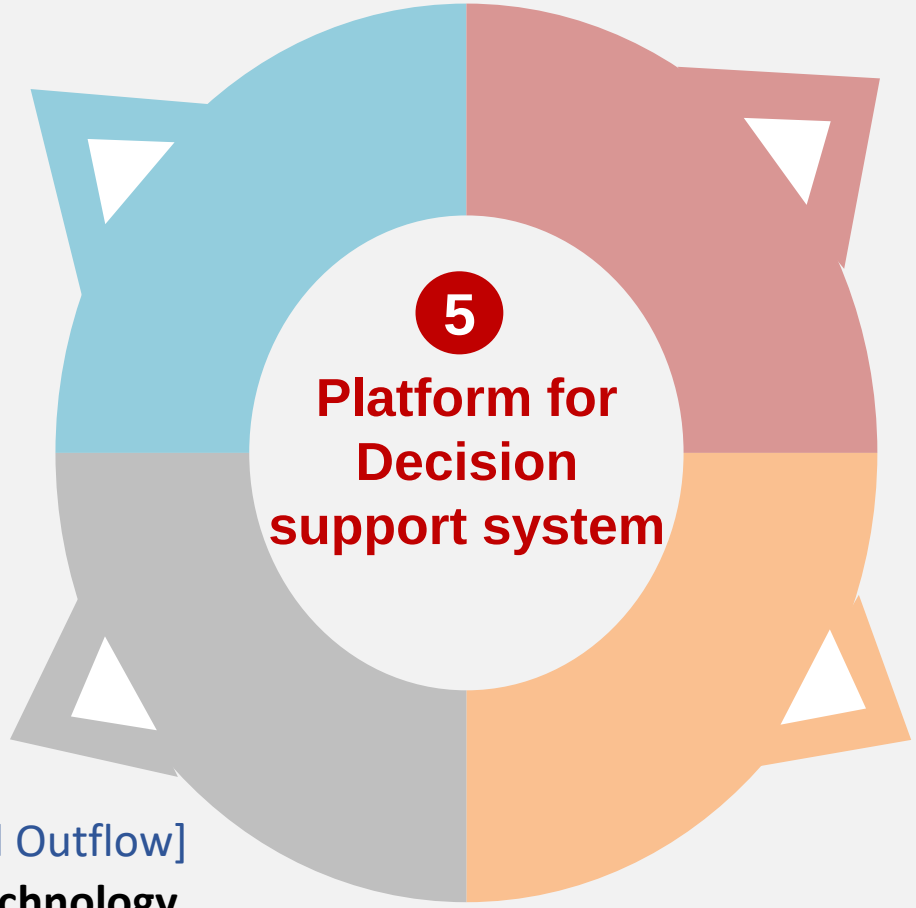
[Water Level, Rainfall, Inflow and Outflow]

- **Advanced dam monitoring technology**

[Dam optimization, Reservoir operation, ECMWF Forecast]

- **Forecasting and Early Warning**

[Runoff/Inundation, Hydrological Modeling, Flood/Drought]



3 Hydrometeorology risk assessment and prediction

- **Climate change projection**

[ECMWF]

- **Flood and Drought Risk**

[Flood risk and drought risk maps]

- **Sectoral vulnerability and risk assessment**

[Hazard, Vulnerability, and Exposure maps]

4 Early Warning and risk Communication

- **Risk advisory**

[community awareness and Urban Safety]

- **Alert/Warning message**
- **Rainfall forecasting**

[No rain and Heavy rainfall]

Integrated Approach for Risk Communication and Reduction

Considering Multi-drivers affecting the flood risk management and disasters

Cagayan Operation

Suspended Sediment

Water Level

Discharge

Inflow

Outflow

Demand/Supply

Energy

Hydropower

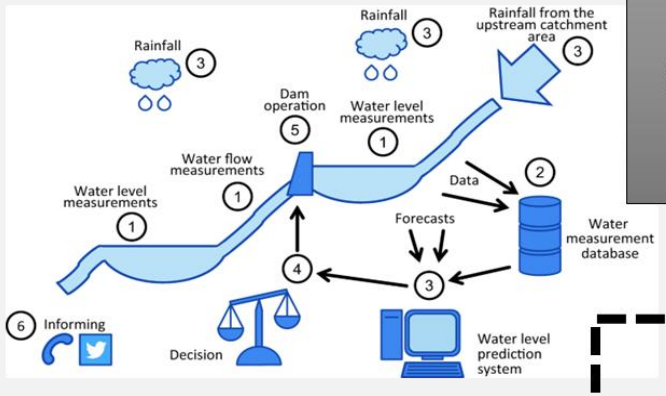
Dam Behavior Monitoring

Dam Safety

Water storage & Pre-release

Flood and Drought Risk

Multi mitigation measures for flood and sediment



Warning Risk and Community Safety

Alert Message

Early warning

Risk Advisory

Disaster Risk Reduction

AI and Decision Making Server

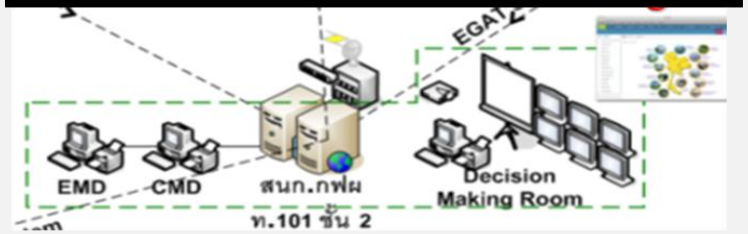
Rainfall forecast

Hydrographs

Inundation

Flood routing

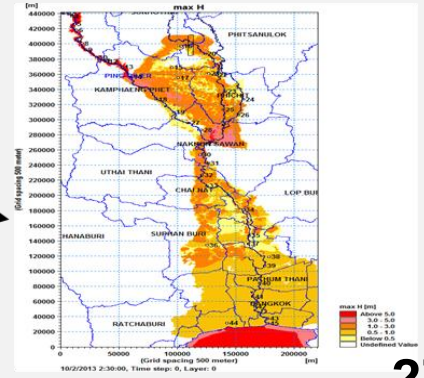
Ensemble Forecast and Hydrological Modelling



Flood & Urban Risk

Alert and Warning Message

Inundation Risk



The concept of sustainable dam and reservoir operation

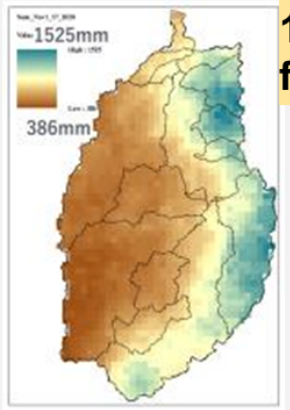
Accurate Rainfall Prediction

Model Development

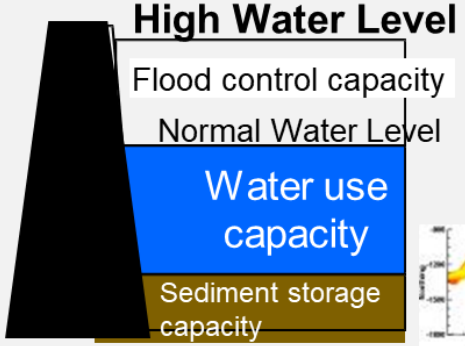
Field survey

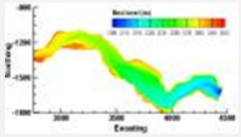
Data Analysis

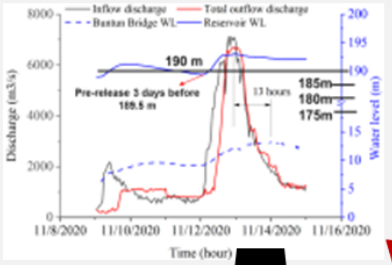
Data Archival & Numerical Modelling



1- Optimization of Dam Operation Rule for Flood and Drought Risk Management

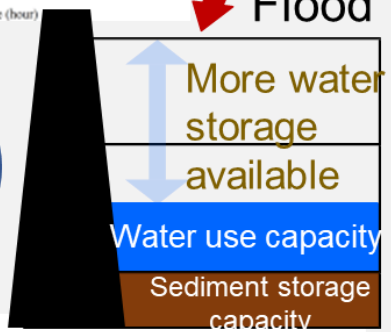




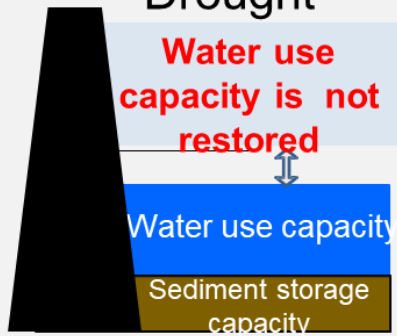


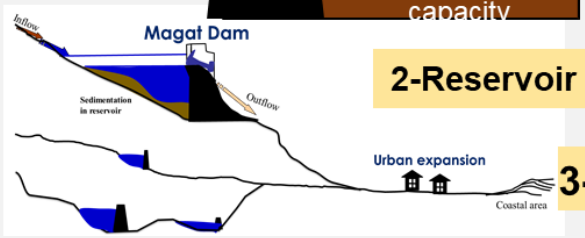
Dam pre-release based on rainfall runoff modelling

Flood



Drought

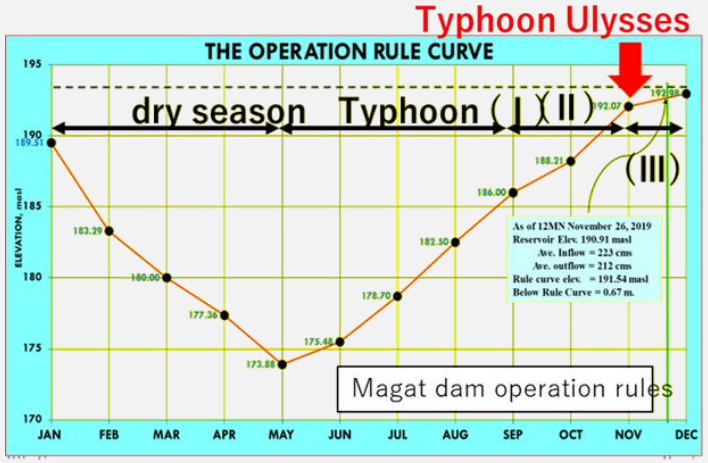


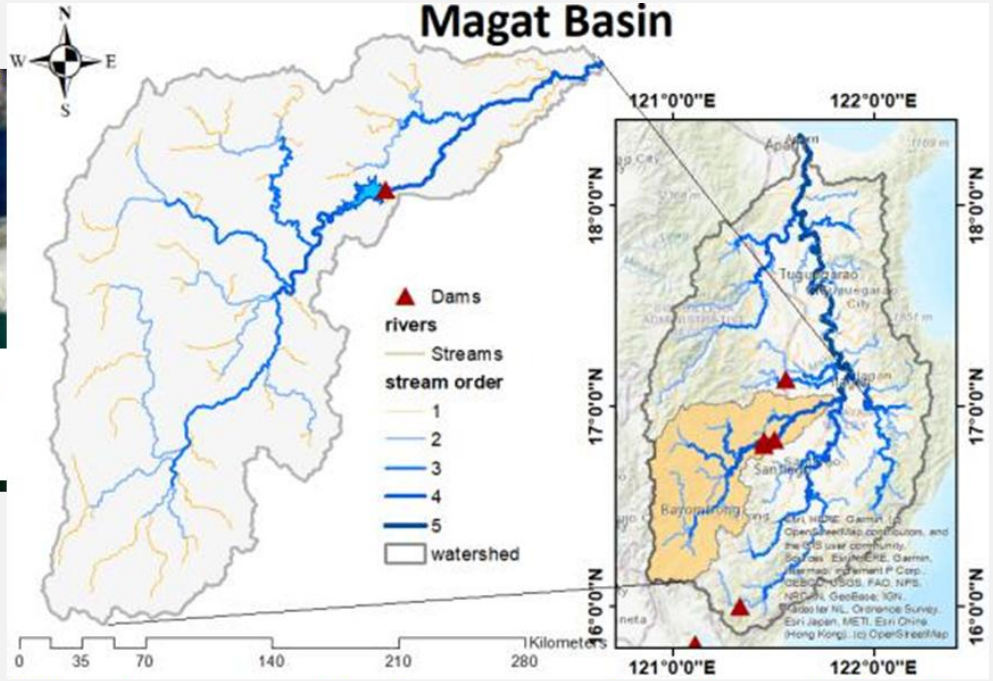


2-Reservoir Risk Management

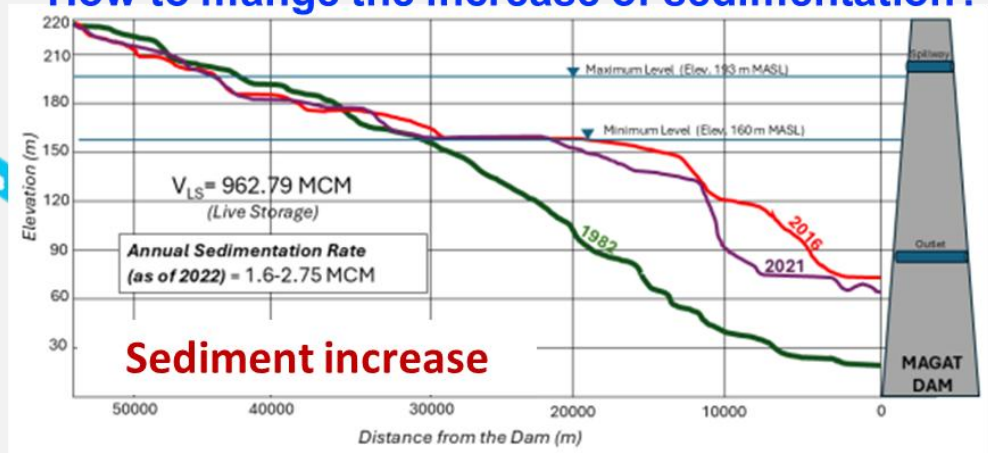
3- Dam Upgrading

Upgrading dam operation and Reservoir Sustainability





How to mange the increase of sedimentation?



Expected Outcomes of NEXUS Project

Scientific

- Predication of extreme hydrometeorological events based on ECMWF data.
- Assess the impact of current and future climate on water resources.

Technological

- Application of several advanced tools for forecasting, planning, and optimizing water resources.
- Develop a Decision Support System (DSS) platform for dam operation.
- optimize dam operation rules

Social

- Public awareness and education.
- Build capacity for water professionals.
- Provide training on RRI and SWAT models.
- Offer professional development opportunities for graduate students.

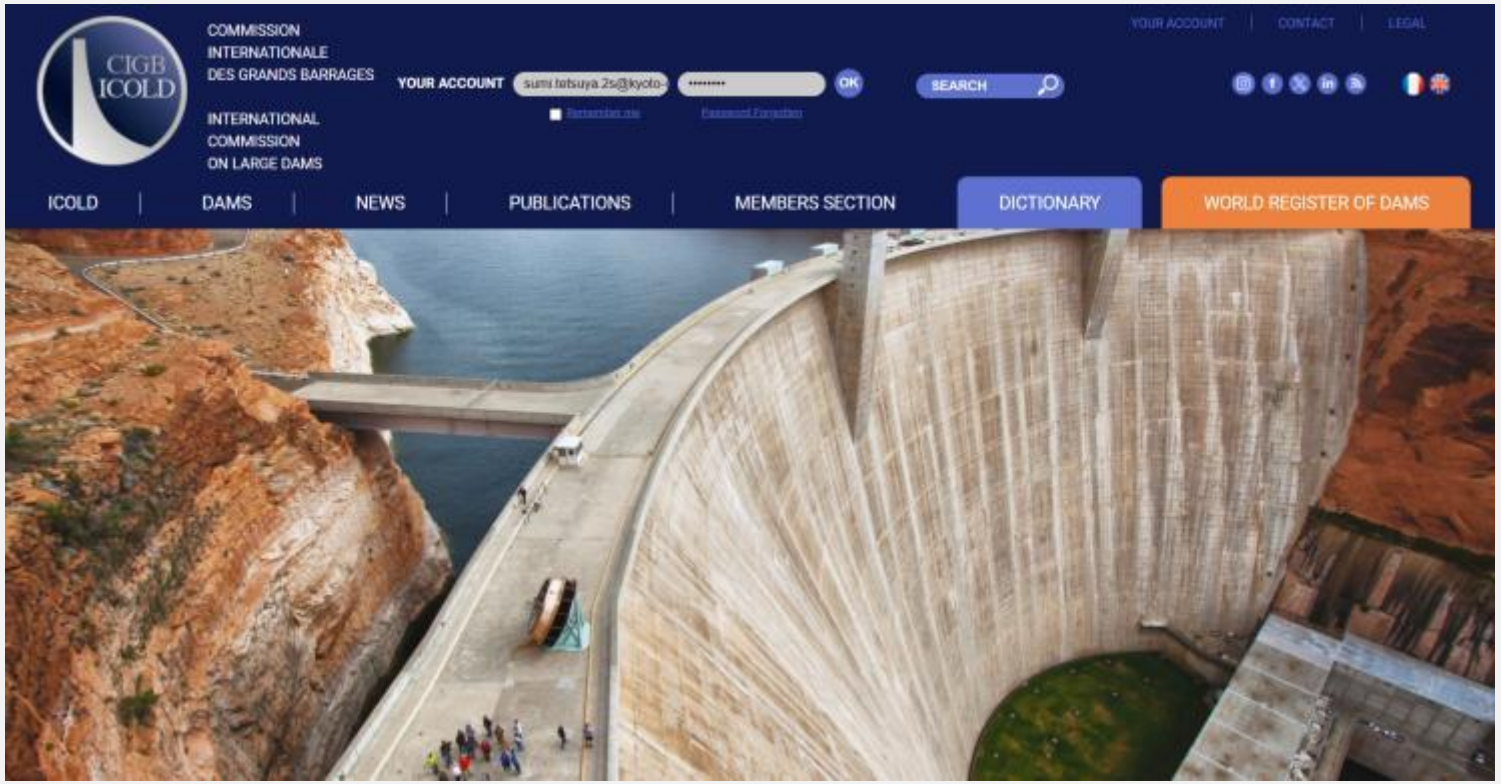
Economic

- Reduce agricultural and infrastructural damages.
- Increase agricultural productivity.
- Increase overall economic growth.

Industrial

- Collaborate with Japanese companies, such as the Japan Weather Association, to develop business opportunities with the National Irrigation Administration (NIA).
- Publish at least two papers in high-impact journals.
- Produce five policy papers for adoption by local government units (LGUs) and River Basin Management Councils.

International Commission on Large Dams (ICOLD)



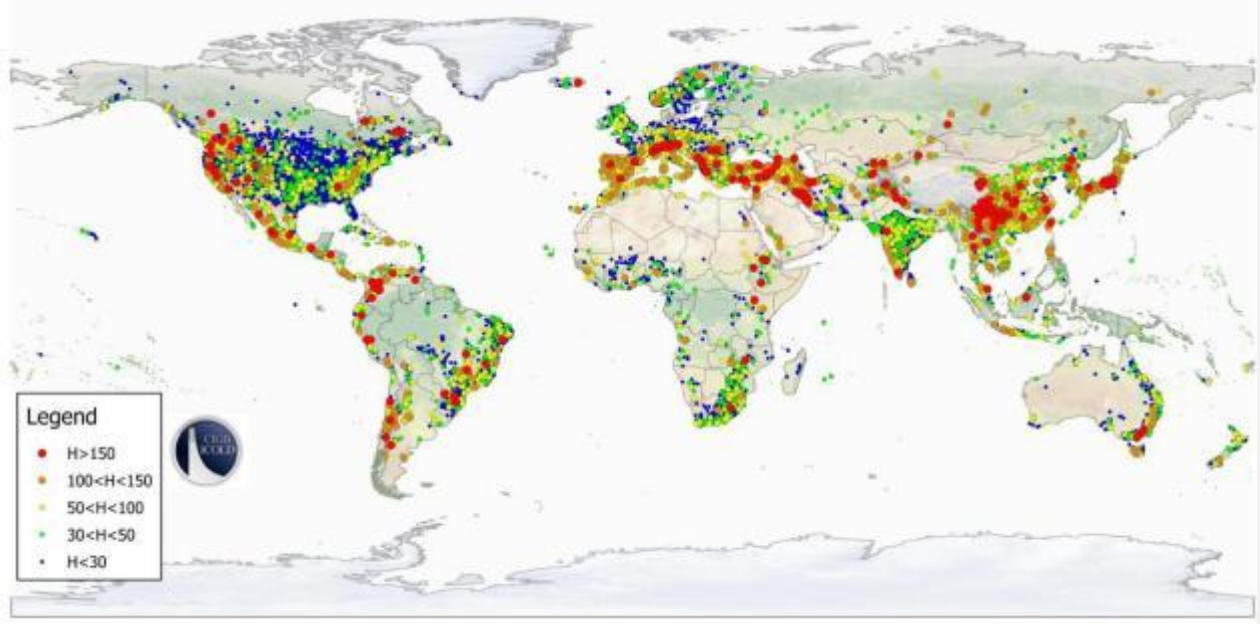
106 Member Countries, 27 Technical Committees

Congress/3yrs, Annual meeting

Asia Pacific Group: Afghanistan, Australia, Bhutan, China, Georgia, India, Indonesia, Iran, Iraq, Japan, Kyrgyzstan, South Korea, Laos, Lebanon, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Russia, Sri Lanka, Syria, Tajikistan, Thailand, Türkiye, Uzbekistan, Vietnam

The role of dams in the energy transition and climate change adaptation

Major challenges for dams and reservoirs



Dams worldwide
World Register of Dams (ICOLD)

1. **Sustainability of existing dams**
   - It is critical to maintain our 60.000 existing dams.
   - Dam safety of an aging portfolio of dams is a big concern.
   - Efficient water management, maintenance, rehabilitation, reengineering of existing facilities to meet the future use.
   - Sedimentation management to be improved
2. **Implementation of sustainable new reservoirs**
   - Reduction of carbon footprint of dam construction
   - New approaches for sedimentation control
   - New type of dams : off-river dams, dams at sea, dam raising…
   - Preservation/ improvement of the biodiversity
3. **Public acceptance**
   - E&S impacts mitigation,
   - Fair share of the benefits among stakeholders
   - Fair comparison between the solutions
   - Improved communication with the public, the media and the decision makers.

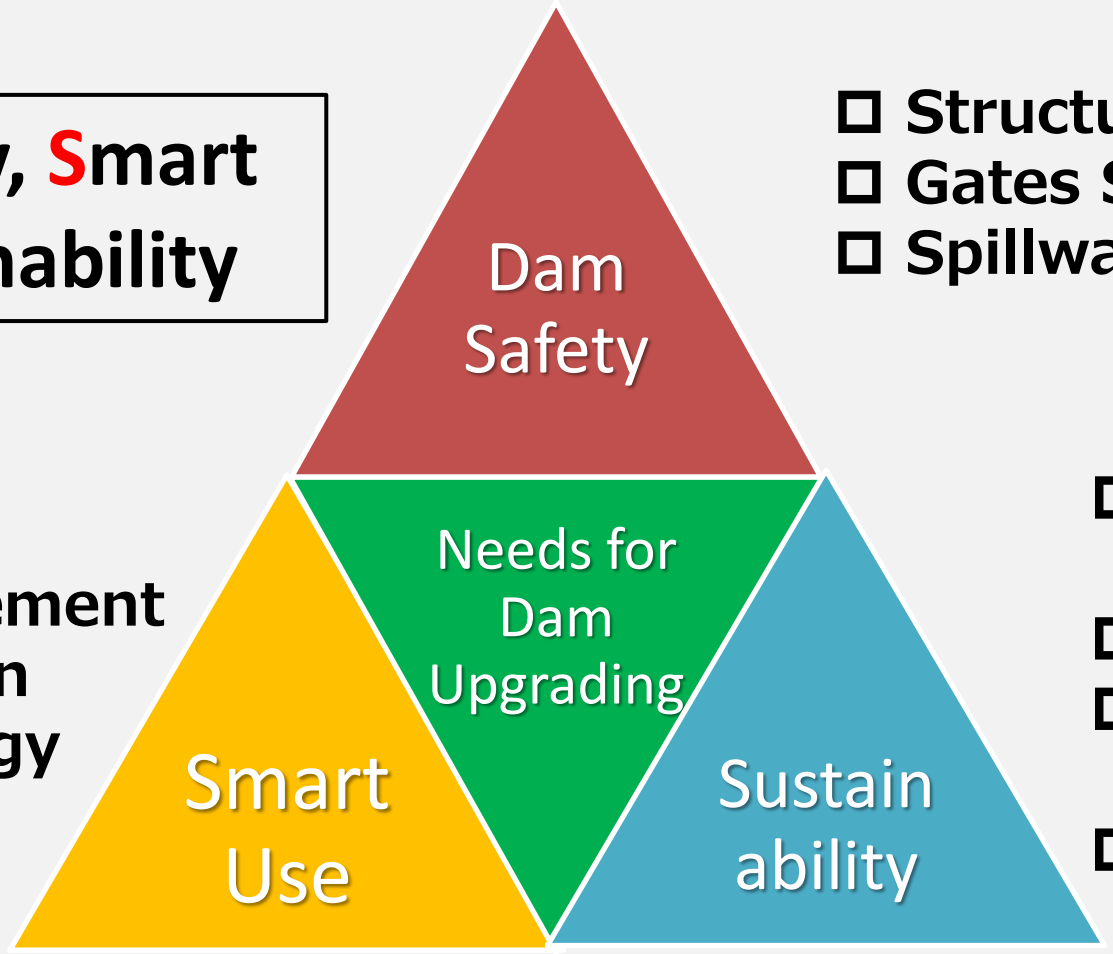
Source: M. Lino (ICOLD)

Key message from ICOLD

Dam Upgrading to be fit for future challenges

Increasing Climate Resilience and Sustainability, and contributing to Energy Transition

Three S : Safety, Smart use and Sustainability



- Structural Safety
- Gates Safety
- Spillway Capacity

- Flood Mitigation
- Drought Management
- Energy Transition
- Renewable Energy
- Pumped Storage

- Reservoir Sedimentation
- Reservoir Water Quality
- Connectivity of Aquatic Lives
- Biodiversity

Recommendation

- Create updated module how to manage river basin for climate resilience and energy transition through JASTIP and NEXUS Project focusing on Magat Dam in Cagayan River Basin.
- Japanese group can collaborate based on cutting edge research outcomes on dam upgrading projects in Japan.
- This approach can be expanded to other river basins and dams in the Philippines, and other ASEAN countries.
- These approaches will be presented in global network such as ICOLD, WWF and others.
- Project implementation will enhance the following networking and capacity buildings.
  - Networking among Japanese and the Philippines Universities and Researchers
  - Bridging Japanese Company with the Philippines Industry
  - Capacity building in Universities, Local Government and Communities etc.