United Nations
Educational, Scientific and
Cultural Organization

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

Hydrological Modeling Framework for Climate–resilient Water Resources and Disaster Managements under Changing Climate

On behalf of Water-related Hazard Team: Hydrology Division
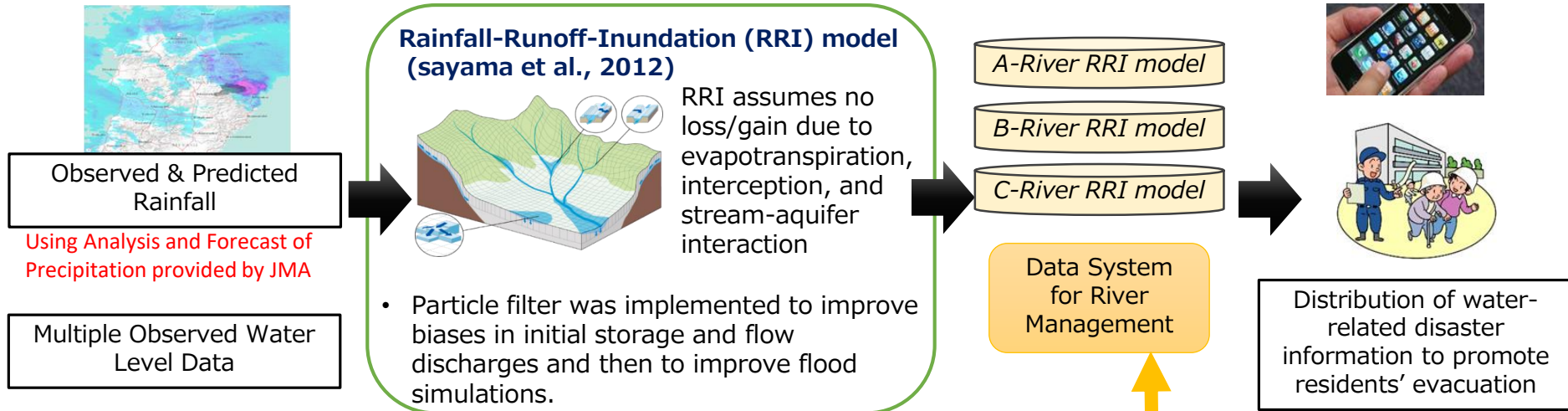
Dr. Mohamed Rasmy

Senior Researcher,

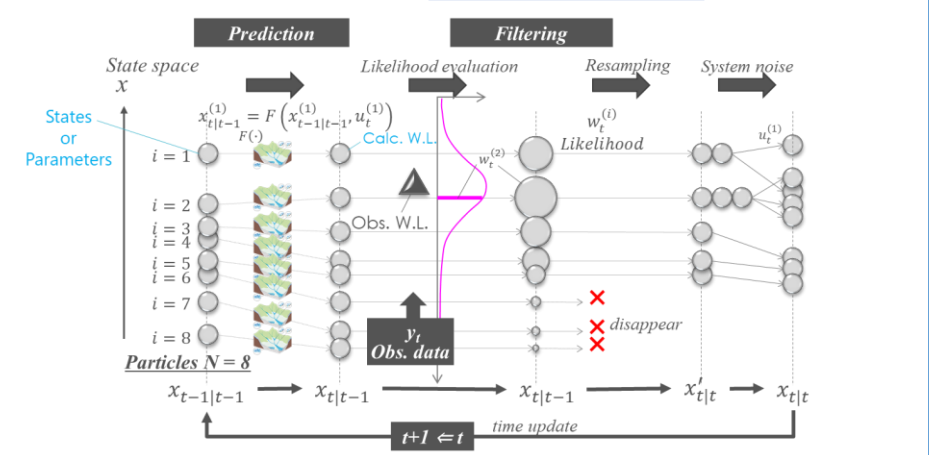*Water-related Hazard Team*

Professor, GRIPS

- Water-related disasters (i.e. floods and droughts) are on increasing trend, particularly the lower-middle income countries become more vulnerable.

- Reliable and timely information on water-related disasters and water availability is a key
  - To develop an affordable and proactive IWRM plans and Disaster Risk Reduction (DRR) strategies
  - To ensure the security of water availability and food productions
  - To achieve sustainable development goals and prosperity for all !

- ICHARM's hydrology team is developing several cutting-edge tools and systems for implementing integrated approaches for climate-resilient IWRM & disaster managements under changing climate

Development of a Simple, Inexpensive Flood Forecasting System for Small and Medium Rivers

◆ **Real-time flood prediction models** focusing on **"Information on the river water levels that required evacuation"** to support the evacuation of residents during floods in small and medium rivers in Japan.

◆ Develop and provide a tool that enables prefectural river managers to handle and predict timely water-level, easily.

Observed & Predicted Rainfall

Using Analysis and Forecast of Precipitation provided by JMA

Multiple Observed Water Level Data

Rainfall-Runoff-Inundation (RRI) model (sayama et al., 2012)

RRI assumes no loss/gain due to evapotranspiration, interception, and stream-aquifer interaction

- Particle filter was implemented to improve biases in initial storage and flow discharges and then to improve flood simulations.

A-River RRI model

B-River RRI model

C-River RRI model

Data System for River Management

Distribution of water-related disaster information to promote residents' evacuation

Particle filter

State space X

States or Parameters

$x_{t|t-1}^{(1)} = F\left(x_{t-1|t-1}^{(1)}, u_t^{(1)}\right)$

$F(\cdot)$ Calc. W.L.

Prediction — Likelihood evaluation — Resampling — System noise

$w_t^{(i)}$ Likelihood

$w_t^{(2)}$

Obs. W.L.

$u_t^{(1)}$

$i = 1$
$i = 2$
$i = 3$
$i = 4$
$i = 5$
$i = 6$
$i = 7$
$i = 8$

y_t Obs. data

× disappear

Particles N = 8

$x_{t-1|t-1} \quad x_{t|t-1} \quad x_{t|t-1} \quad x'_{t|t} \quad x_{t|t}$

$t+1 \Leftarrow t$ — time update

· Since PF can handle non-linear models, we don't need rewrite hydrological model linear-equation like a Kalman Filter (KF).

· PF estimates state-space/parameters (water-level on slope and in rivers).

Real time flood forecasting system

Select water level observation point from a map of Japan

Observed water level   Predicted water level

· Forecast: for 6 hours, Update interval: every 30 minutes
· Visualize the results on an internet based-system and allow public access to the web-page

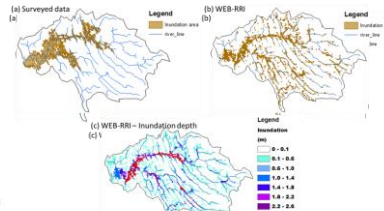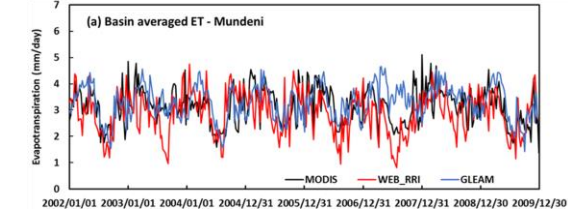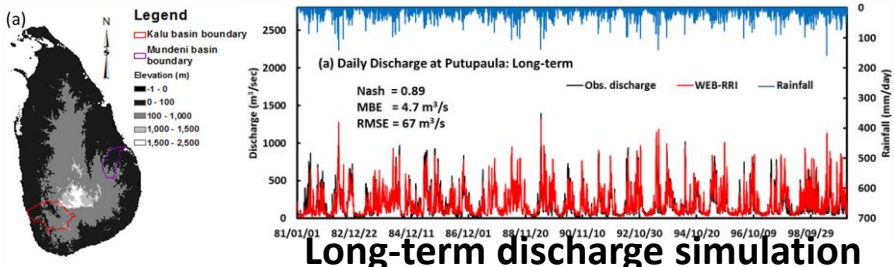# Seamless Modeling Approach : IWRM under changing climate

❑ **ICHARM has developed a highly reliable hydrological model for addressing various water-related issues, to strengthening water-related disaster resilience, water resources management and then enabling sustainable development under climate change:**

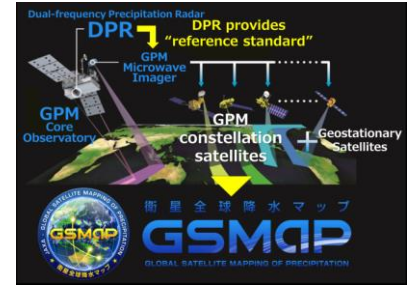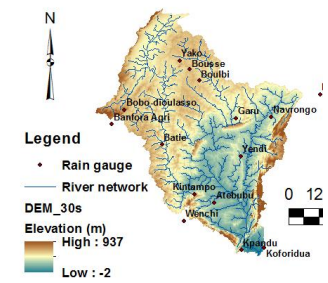**Water and Energy Budget based Rainfall-Runoff-Inundation (WEB-RRI) model (Rasmy et al., 2019)**

4-components model
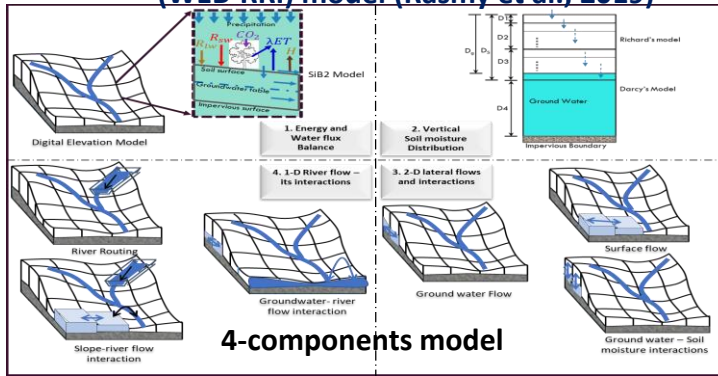
• Physical formulations for ET and soil moisture dynamics for reliable of flood and drought related risk assessments

Application 1: West- Africa(Niger & Volta basins)

Predictions in Ungauged Basins (PUB)

Verification in Kalu basin, Sri Lanka

Long-term discharge simulation

Evapotranspiration estimation   **Inundation**

Application 2: Philippines (Pampanga)

Seamless Modeling Approach

Drought monitoring & seasonal prediction system

Drought monitoring & seasonal prediction system

Satellite microwave sensor - AMSR2 -

Meteorological forcing

LDAS

Precipitation

Seasonal prediction

+

Seasonal predicted meteorological forcing

Microwave brightness temperature

Satellite   Simulation

RTM

Eco-hydrological variables

Land surface model - EcoHydro-SiB -

Land surface model - EcoHydro-SiB -

Assimilation scheme - Genetic Particle Filter (GPF) -

$$\text{Cost} = \sum_{f=6.18GHz} \sum_{P=H,V} \left(TBsim_f^P - TBobs_f^P\right)^2$$

Minimized cost   NO   **UPDATE Initial condition Eco-hydrological variables**

YES   **Optimized eco-hydrological variables**

Initial input from monitoring

Seasonal predicted eco-hydrological variables

OUTPUT

Optimum irrigation water

Crop yield

Application to agricultural support information

Land surface Soil moisture   ET

Root-zone Soil moisture   LAI

Monitoring   **Seasonal prediction**

Soil moisture(m³/m³)

**Monitoring**   **Prediction**

Brazilian Northeast.

-System monitors soil moisture profiles and crop growth and predict them for up to approximately three months ahead.

-It can also estimate water requirement to maximize crop yields.

-Locally, drought status is determined through monitoring and seasonal prediction from this system, and the results are used to formulate farming plans.

-it will be further improved to provide information useful for farming.
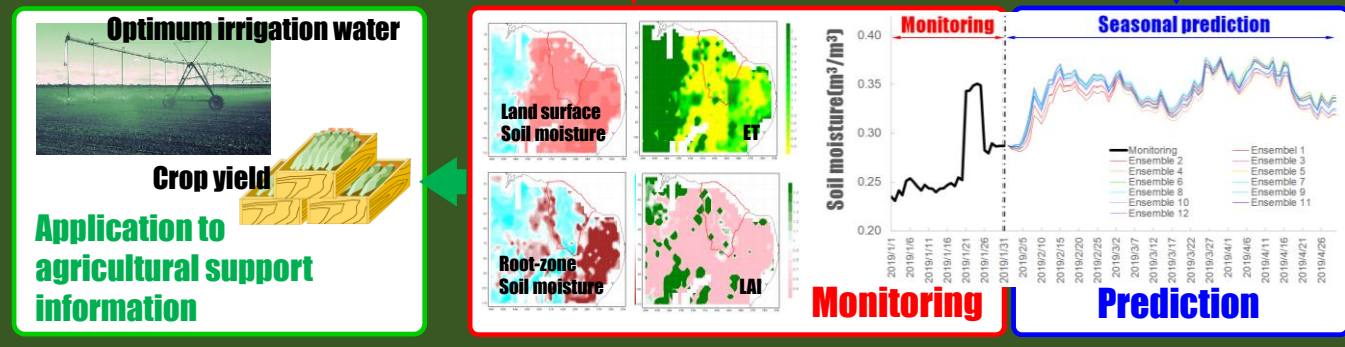
Thank you for your kind attention !!!