Hydrologic Process Understanding and Modeling in the Batanghari River Basin, Sumatra, Indonesia

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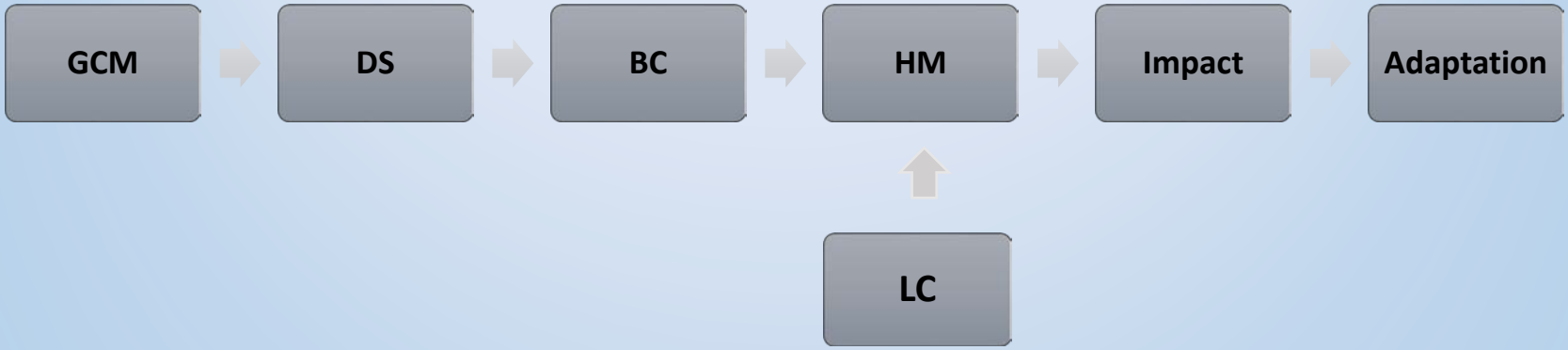
Background

- Climate Change (CC) impacts hydrologic cycle at the river basin scale
- Change in hydrologic cycle may lead to increase frequencies and intensify the severity of water-related disasters such as floods and droughts
- Land-cover / land-use Change (LC) also influences on hydrologic cycle
- A number of stakeholders exist and they need appropriate adaptation strategies for CC and LC

Impact Assessment of CC and LC

Top-down approach of impact assessment of CC and LC



CC: Climate Change

LC: Land-cover / land-use Change

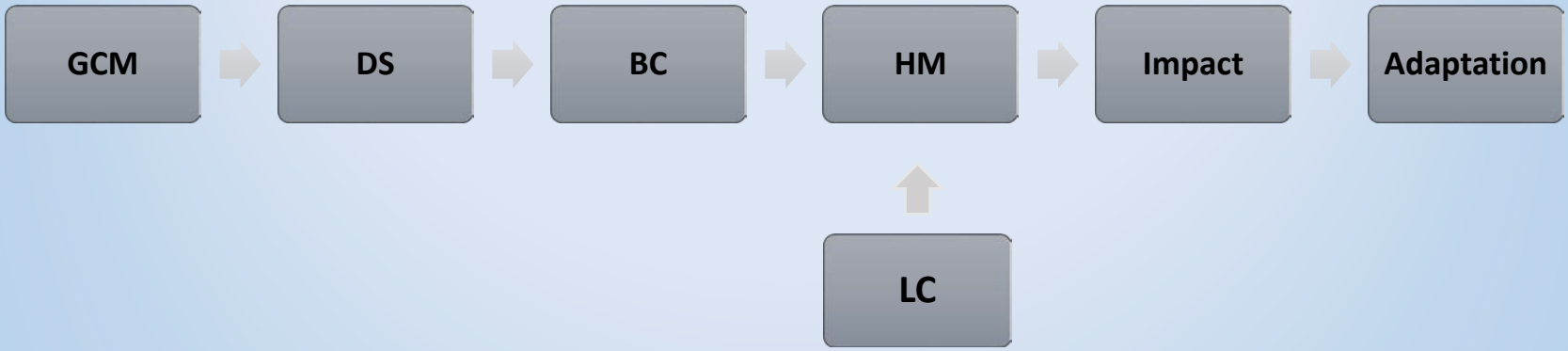
GCM: General Circulation Model

DS: Down Scaling

BC: Bias Correction

HM: Hydrologic Modeling

Issues in the Top-down Approach

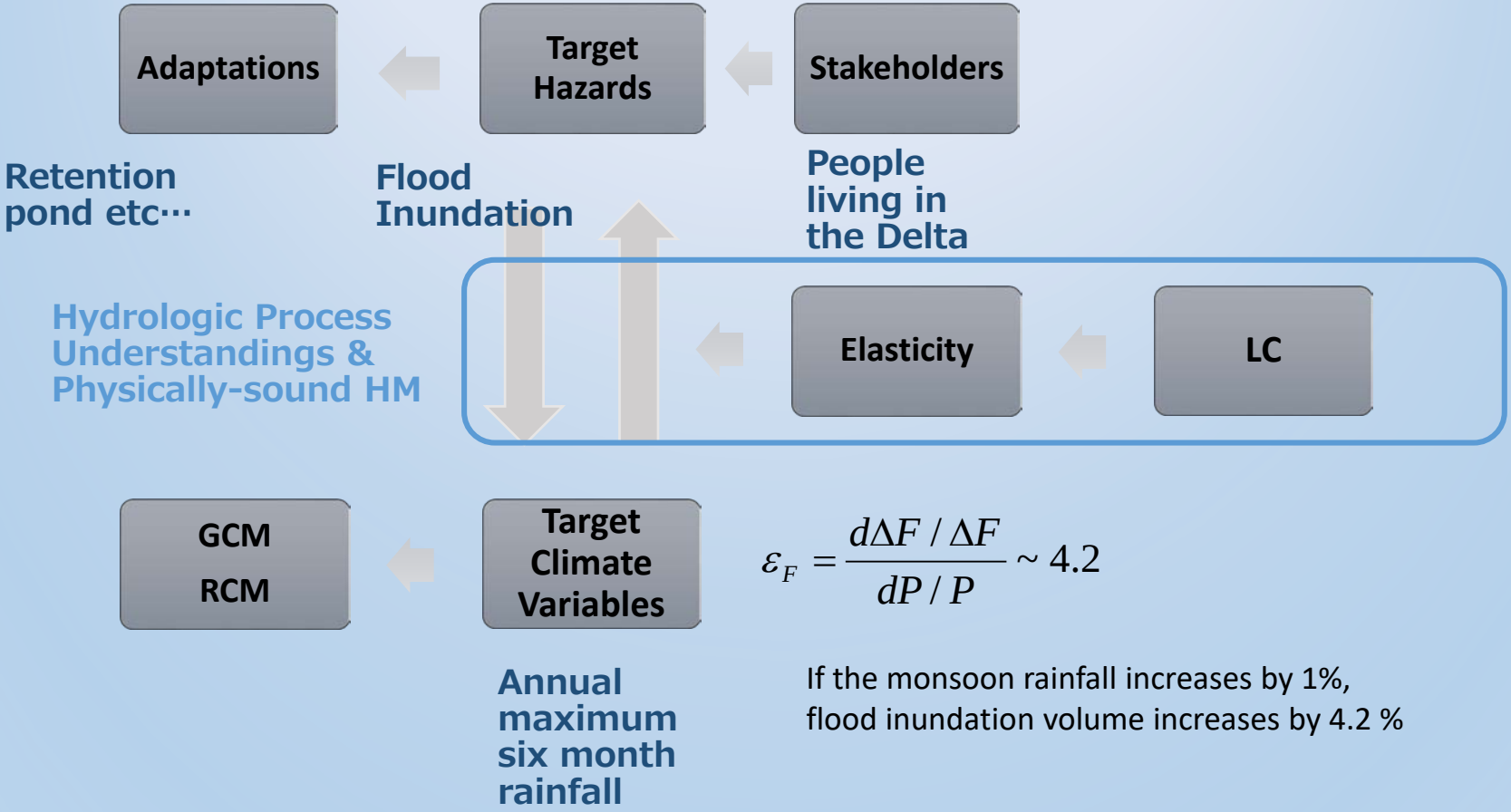


- Uncertainty in GCM, DS, BC, HM, LC
- Impact assessment depend on the selections of each methods
- Rapid progress in CC research has led to significant increase in data and scenarios
- Understanding mechanisms and explaining reasons in changes are typically not very much emphasized
- Some stakeholders may not believe in the projections and refuse adaptation strategies

Bottom-up Approach for CC and LC Adaptations

Case Study in the Chao Phraya River Basin , Thailand

Sayama et al., Hydrologic sensitivity of flood runoff and inundation: 2011 Thailand floods in the Chao Phraya River basin, Nat. Hazard Earth Syst. Sci., 15, pp. 1 – 14, 2015.

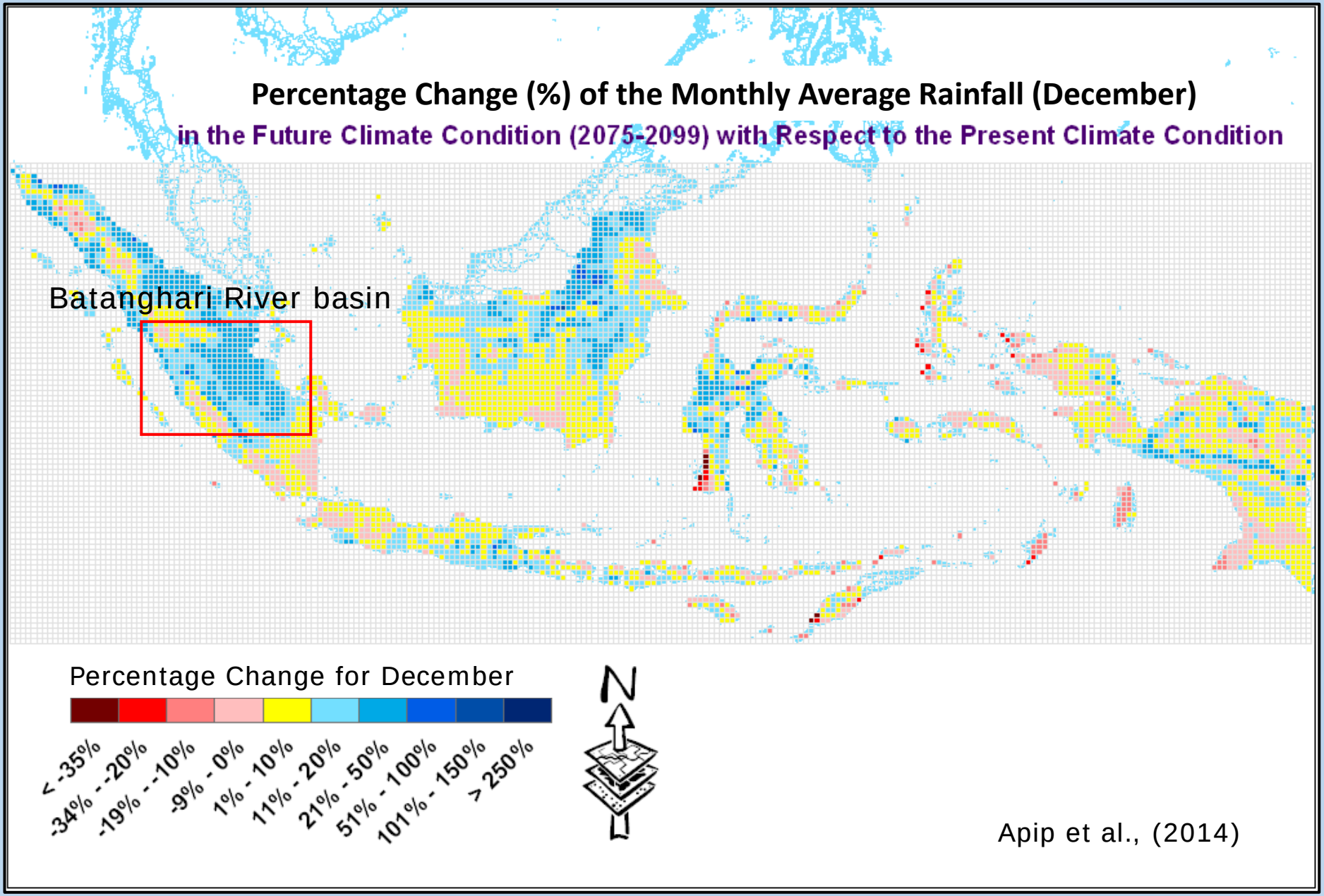


$$\varepsilon_F = \frac{d\Delta F / \Delta F}{dP / P} \sim 4.2$$

If the monsoon rainfall increases by 1%, flood inundation volume increases by 4.2 %

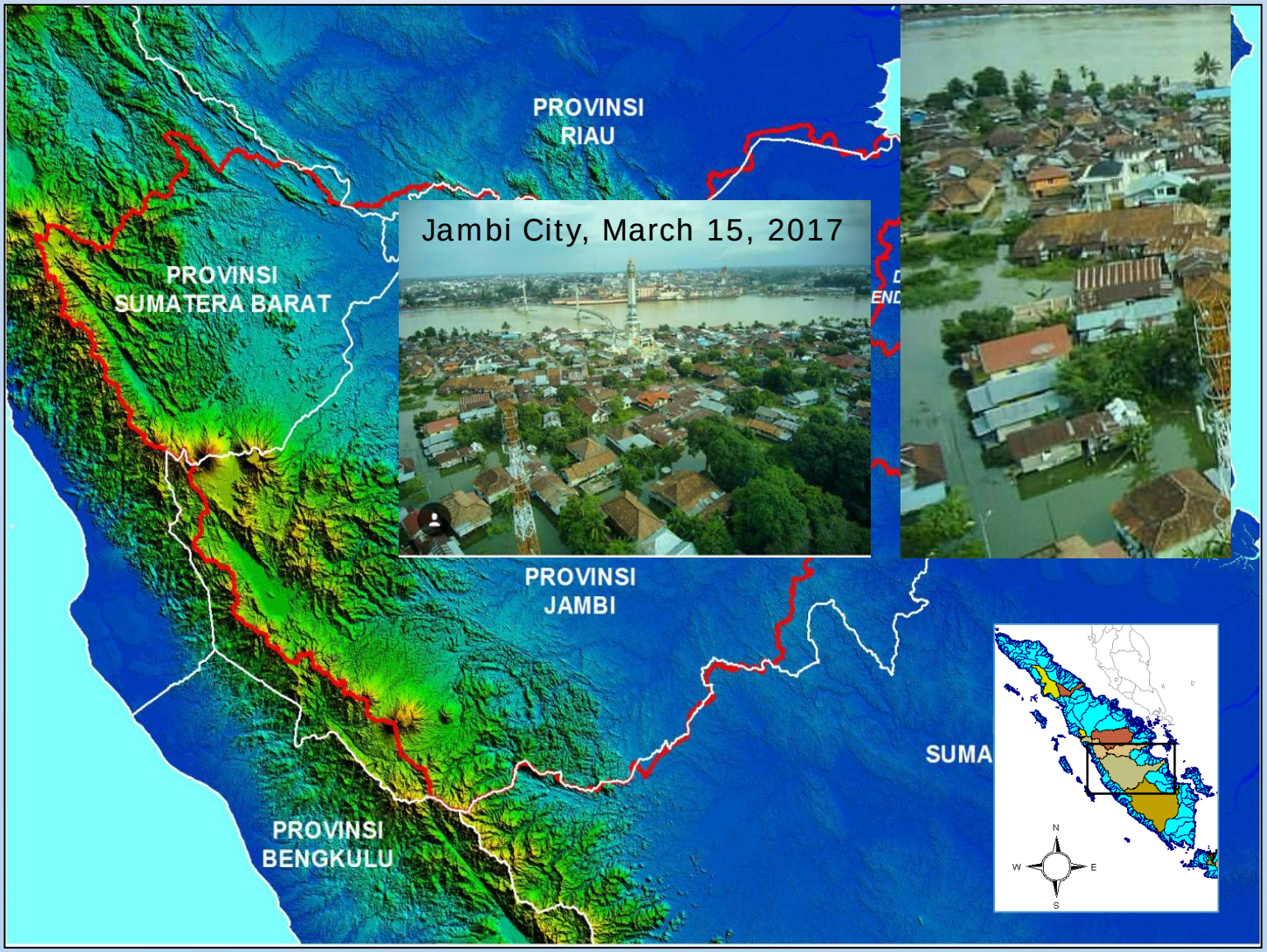
e.g. García, L.E., J.H. Matthews, D.J. Rodriguez, M. Wijnen, K.N. DiFrancesco, P. Ray. 2014. *Beyond Downscaling: A Bottom-Up Approach to Climate Adaptation for Water Resources Management.* AGWA Report 01. Washington, DC: World Bank Group.

Projected Change in Monthly Average Rainfall



Apip et al., (2014)

The Batanghari River Basin



The Batanghari River Basin (42,960 km^2)

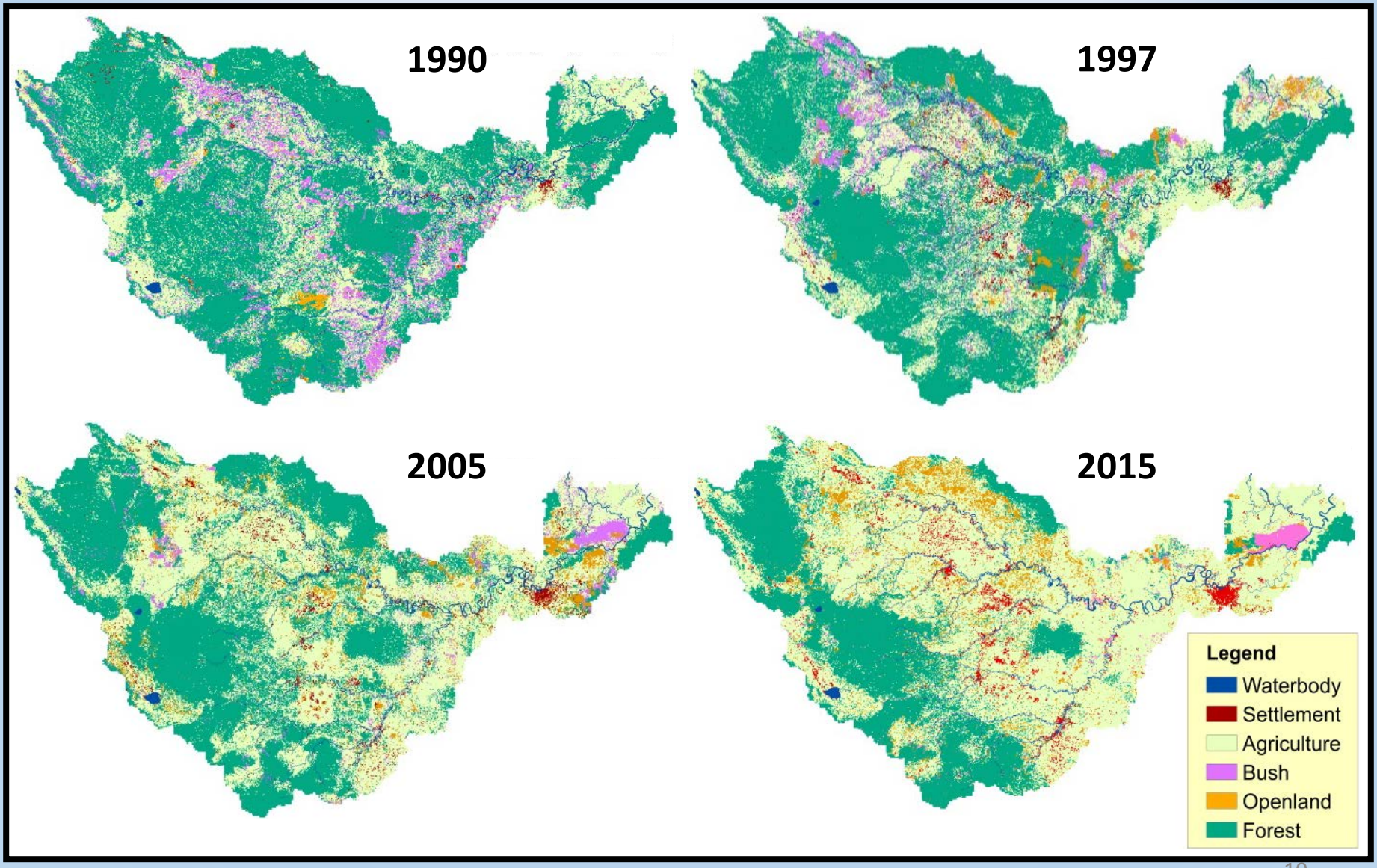
Landscapes in the Batanghari RB

Tropical Forest in Sumatra

Tree Plantations

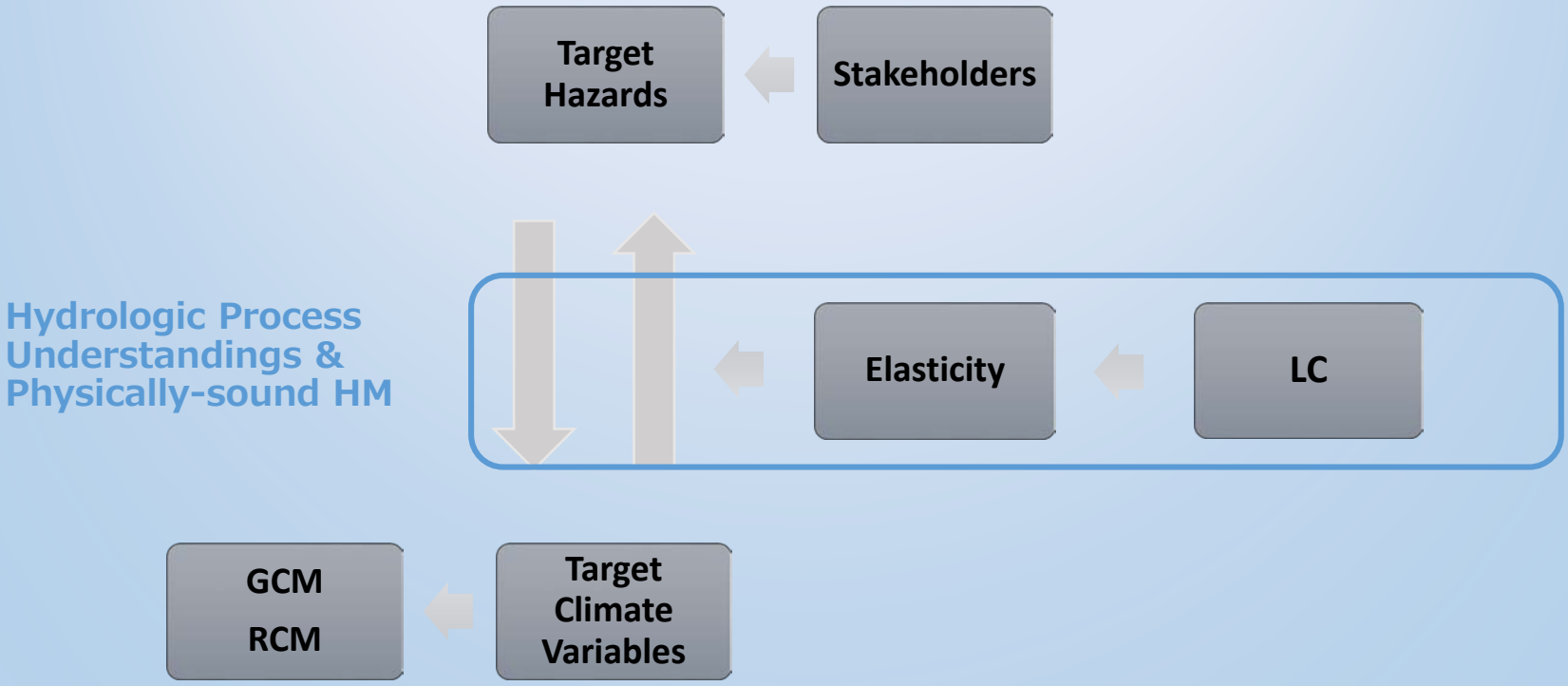
Peatland Area in the Downstream

Land-cover land-use Change (LC)



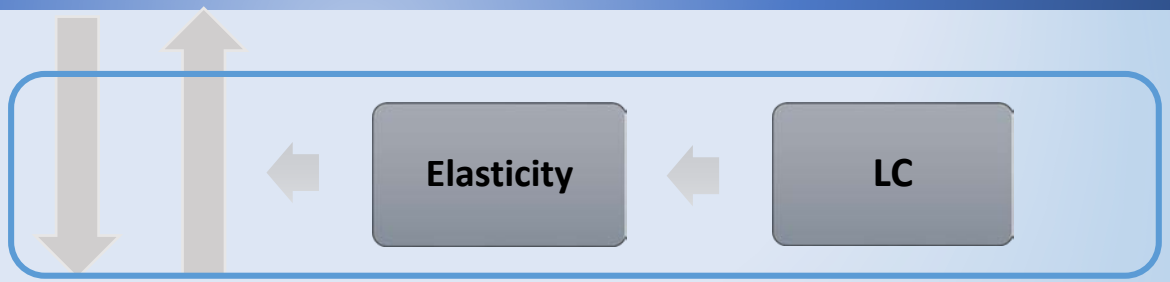
Courtesy Dr Apip

Multi-layered Approach for CC and LC Adaptations

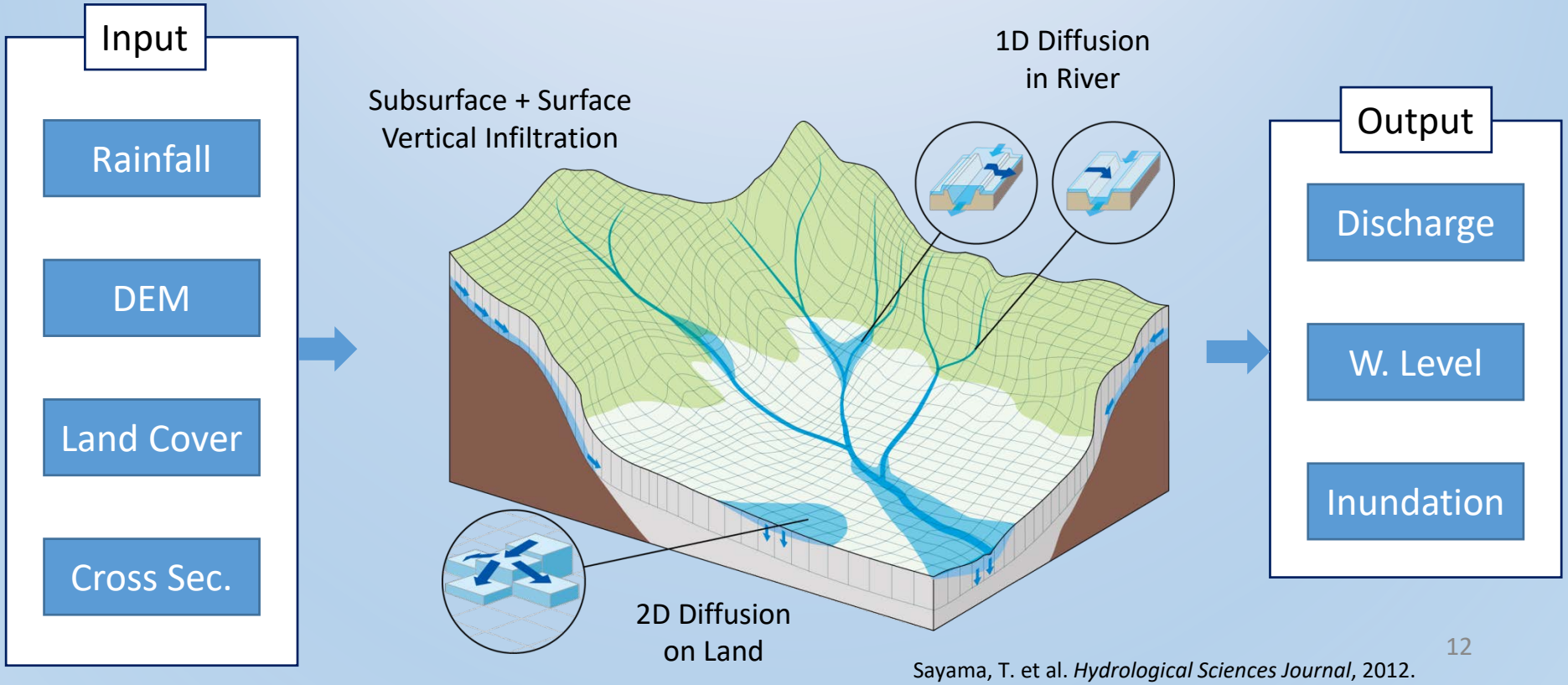


Multi-layered Approach for CC and LC Adaptations

Hydrologic Process Understandings & Physically-sound HM



Rainfall-Runoff-Inundation (RRI) Model



Sayama, T. et al. *Hydrological Sciences Journal*, 2012.

Three Conditions of Surface / Subsurface Flow

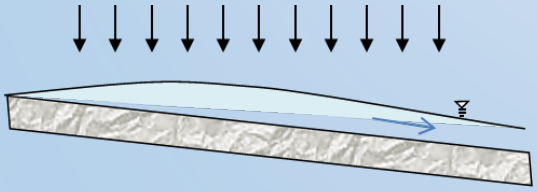
Rainfall-Runoff-Inundation (RRI) Model

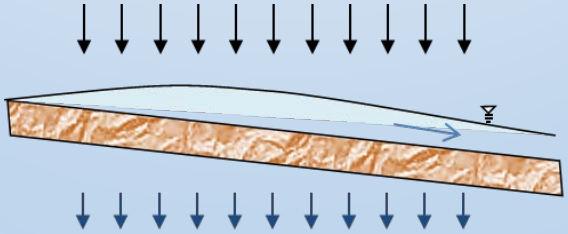
Surface / subsurface flow conditions

(A) Only overland flow (no infiltration loss, no subsurface flow)

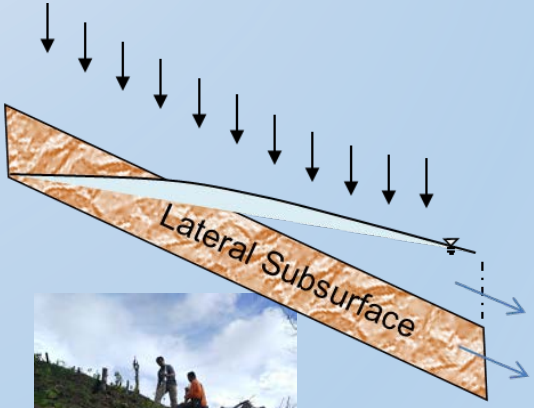
(B) Vertical infiltration + Infiltration excess overland flow

(C) Saturated subsurface + Saturation excess overland flow



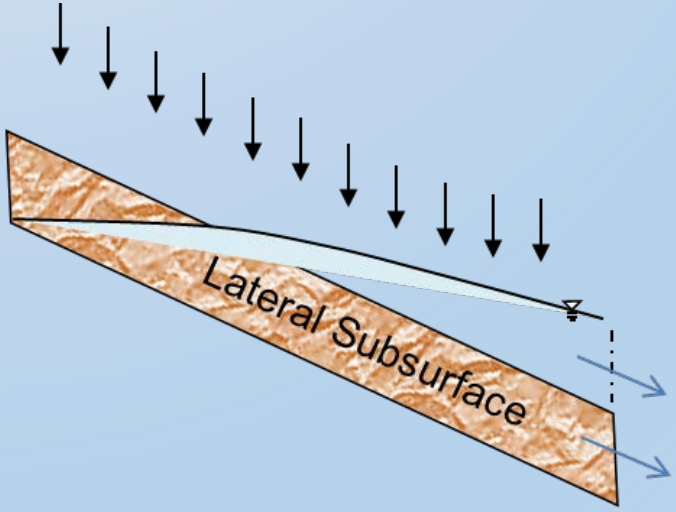


Infiltration : Green Ampt Model

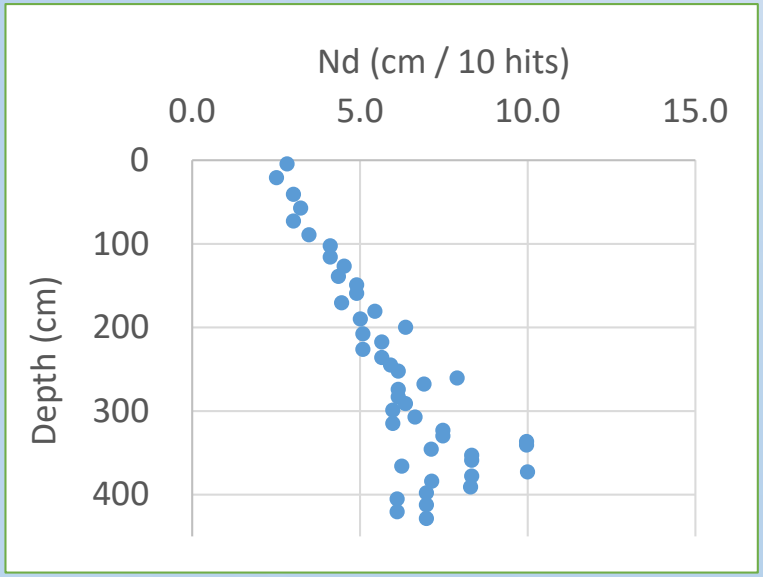


In case of Japanese Forest

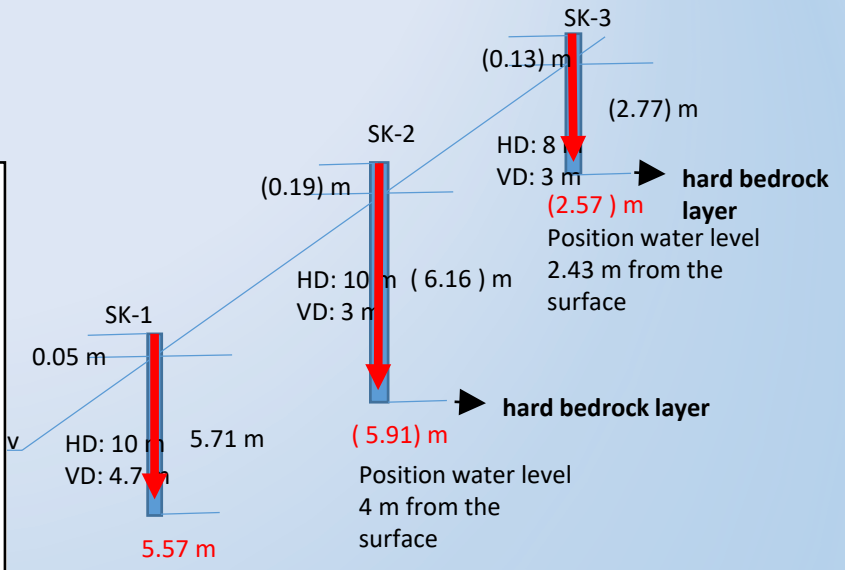
Soil depths: 60 – 100 cm
Underlain by granite bedrock
(Kiryu Experimental Watershed)



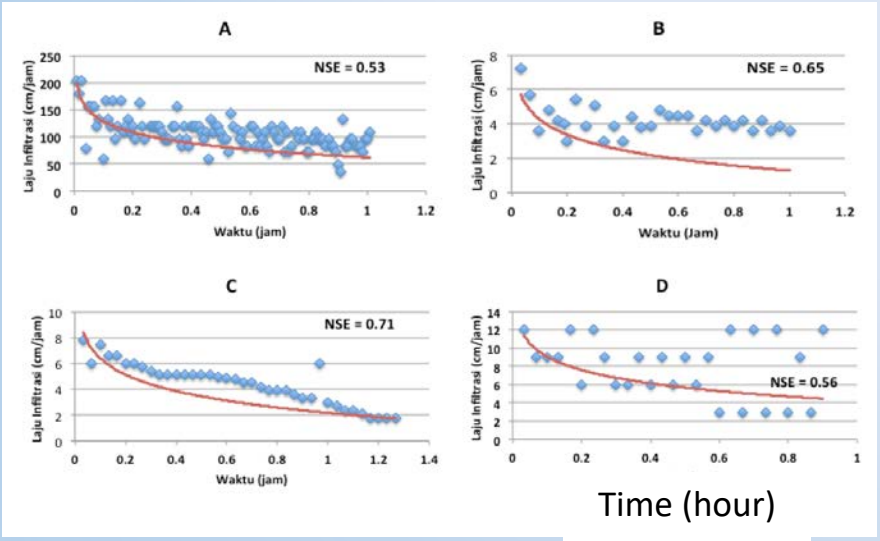
Deep Soil Layer



Well drilling and GW Monitoring

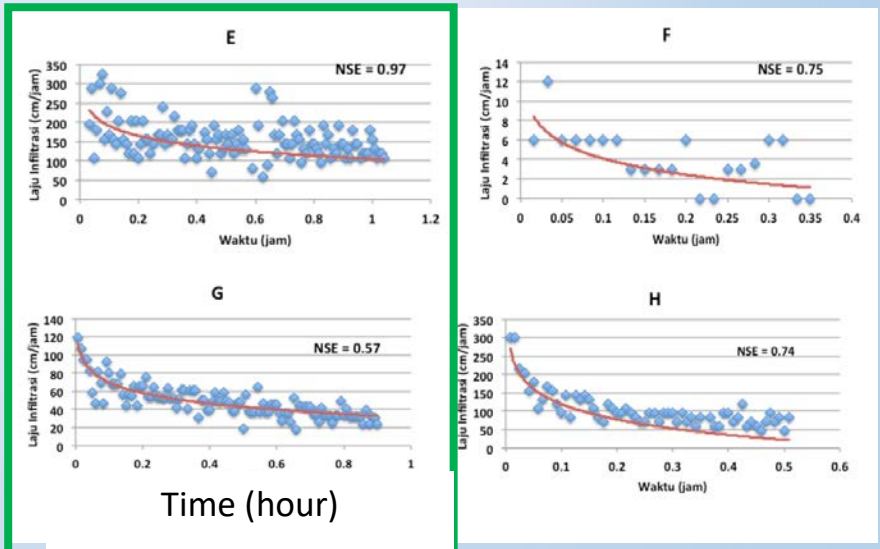


Infiltration Measurement



Time (hour)

Settlement



Time (hour)

Forest & Rubber Plantation

Land-use: A (mixed garden), B and D (settlement), C (shrub), E (city forest), F (bare land), G and H (rubber plantation)

Courtesy Dr Apip

Multi-layered Approach for CC and LC Adaptations

Interviews by Mr. Yamamoto

	Organizations	Concerns	Options
Government	River Basin Management Agency and Protection of Forest, MEF	Deforestation Flood disasters Water quality Illegal mining	Land & water rehabilitation to reduce water related disasters Reforestation Disaster education
	Ministry of Environment and Forestry	Land-use change Environmental impact	Monitoring land-use change
	Ministry of Agriculture	Farmer welfare Sustainable agriculture	Effective agroforestry Poly agricultural system
Private*	APP (Asian Pulp and Paper)	Production of Pulp Environmental impact Relationship with customers and community	Sustainability in production and environment
NGOs	WWF	Deforestation	Take actions and communications
	Warsi	Forest conservation with community	

* Interviews to APP Japan by Karlina and Sayama

Thank You

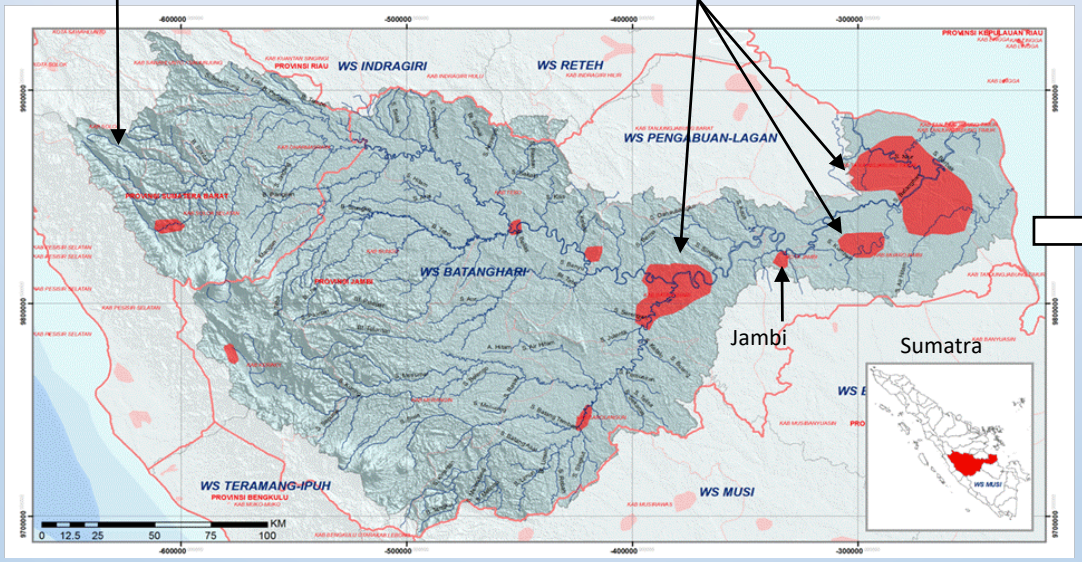
LC and Hydrologic Cycle

Batanghari River Basin (42,960 km^2), Sumatra, Indonesia

Upstream

Natural Forest

Frequent flooding areas, Wetland



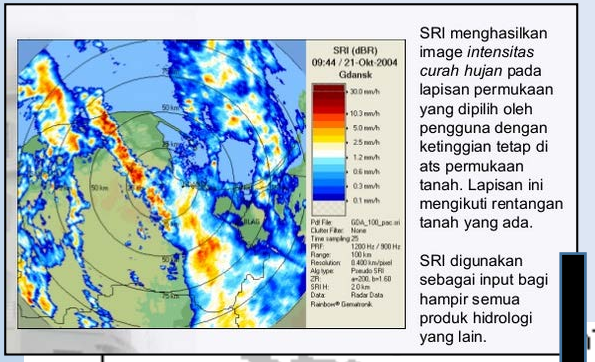
Downstream

Peatland Area

Drying wetland
Peatland fire

1. In Sumatra, **50 % of primary forest has been deforested** in the last 25 years (1985-2009)
2. The deforestation has impacted to the increase of CO_2 emission and **change in the hydrologic cycle**, causing flood and drought disasters, soil erosion and drying lands.
3. In the downstream part of the river basin, where large **peatland** exists, the change in river flow regime as well as artificial drainage system for creating new farmland has dried the area, leading to frequent fire in the peatland area and haze issue.

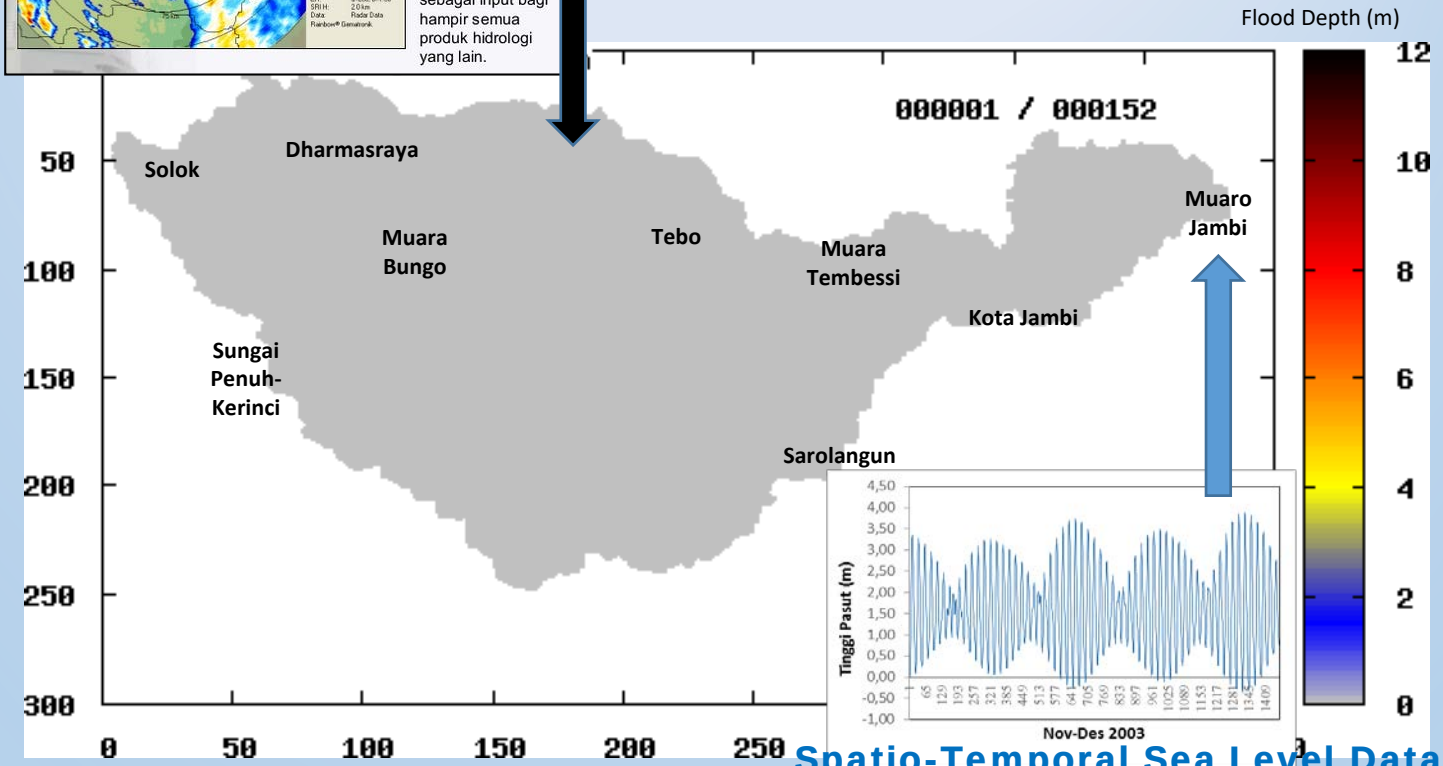
RRI Simulation



SRI menghasilkan image *intensitas curah hujan* pada lapisan permukaan yang dipilih oleh pengguna dengan ketinggian tetap di ats permukaan tanah. Lapisan ini mengikuti rentangan tanah yang ada.

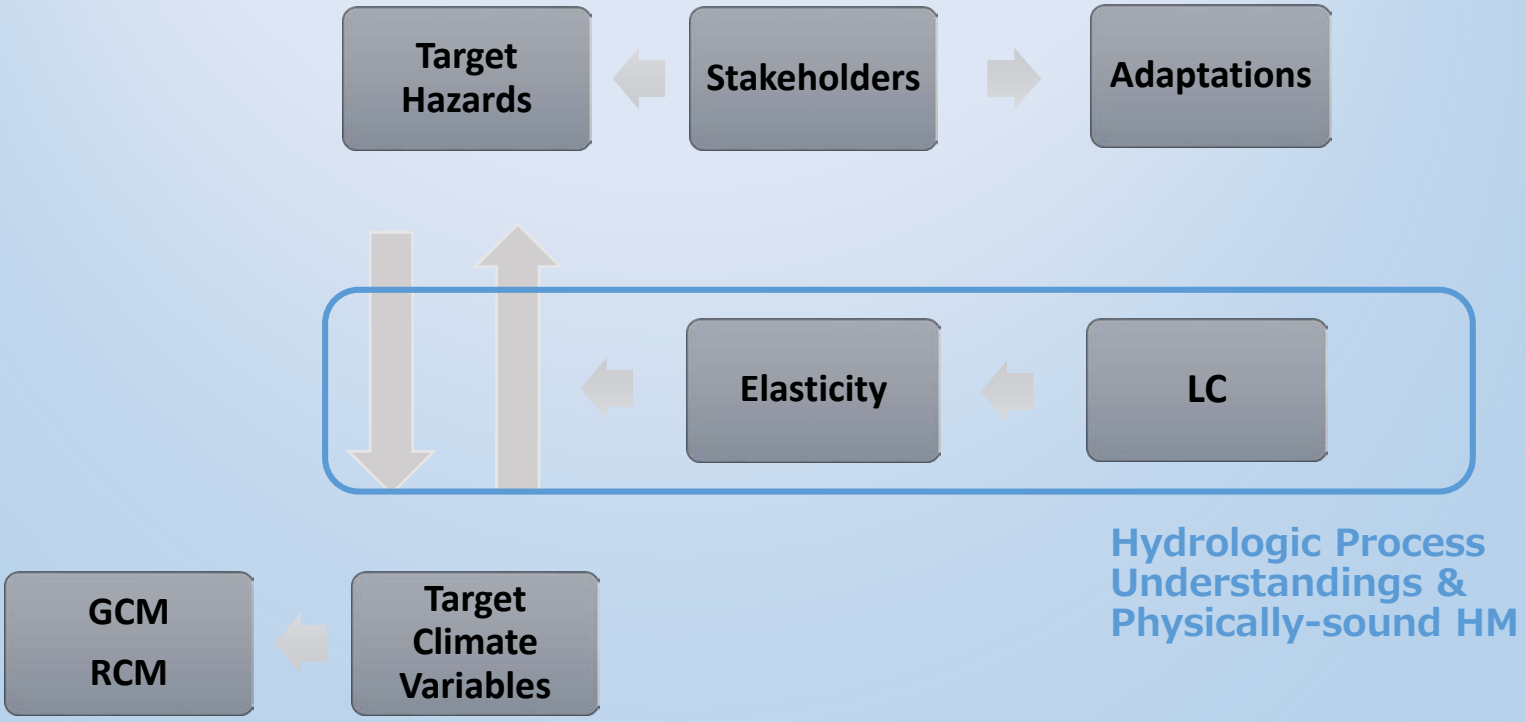
SRI digunakan sebagai input bagi hampir semua produk hidrologi yang lain.

Flood Hazard Assessment for Batanghari River basin

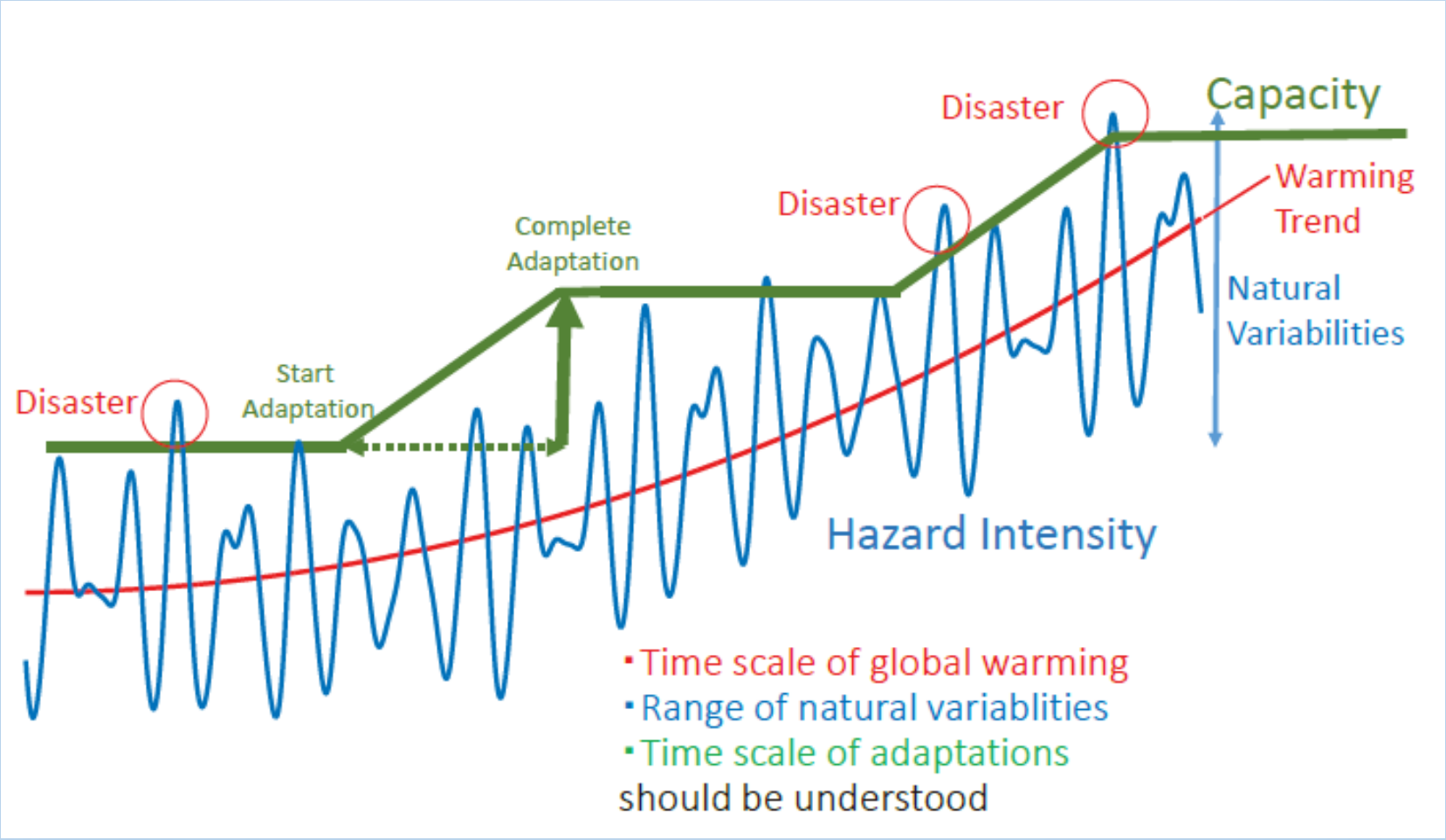


Spatio-Temporal Sea Level Data

Multi-layered Approach for CC and LC Adaptations



100-year Seamless Impact Assessment and Adaptation Strategies



TOUGOU Project: Area Theme D: Integrated Hazard Predition

Outline

- Background
- Impact Assessment (IA) of Climate Change (CC) and Land-cover / land-use Change (LC)
- Problems in the Typical Sequential Approach of IA
- Multi-layered Approach for CC and LC Adaptations
- Study Site
- Current Activities within in this Research Framework
  - Hydrologic Modeling (HM)
  - Field Monitoring for LC Impact Assessment
  - Stakeholder Meetings

Research Projects

- The Japan-ASEAN Science, Technology and Innovation Platform (JASTIP) funded by Japan Science and Technology (JST)
  - Since FY2015
  - WP4: Disaster Research Group
  - Collaborative Research between DPRI, KU and Research Center for Limnology, LIPI

- MEXT KAKENHI (B)
  - Since FY2016
  - “Assessing the Impact of Deforestation in Tropical Forest in Sumatra, Indonesia, on Hydrologic Cycle at the River Basin Scale including Lower Wetland Area” (PI: T. Sayama)

- TOUGOU Project: Integrated Research Program for Advancing Climate Models
  - Since FY2017
  - Area Theme D: Integrated Hazard Prediction (PI: Prof. Nakakita, KU)
  - Hazard Assessment in Asian and Pacific Countries and International Cooperation

Multi-layered Approach for CC and LC Adaptations