Some experiences on regional climate change and variability modeling, rainfall downscaling and flood inundation in Southeast Asia

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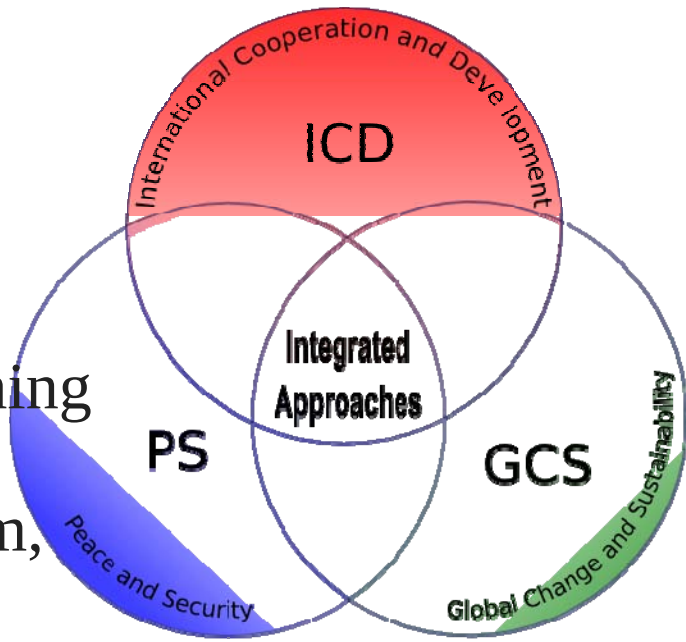
Outline

- About UNU-ISP
- Mekong basin studies
  - Basin water cycle
    - Input
    - Models
    - Results
  - Basin wide research collaboration
- Capacity Development Activities
- Climate change studies and initiatives
  - Challenges and solutions

Institute for Sustainability and Peace

- UNU
  - A think-tank for the United Nations
  - Support Developing Countries
  - Focus on Higher Education
- 14 Research and training Centers worldwide.
- ISP became operational on 1 of Jan, 2009, combining former programs of Environment and Sustainable Development with Peace and Governance Program,
  - Global change and sustainability
  - Peace and security
  - International cooperation and development



http://isp.unu.edu

Research Topics in Asia Addressed at GCS

- Pollutant measurement: 11 country program
- Extreme flood risk assessment: 12 country, 5 ongoing
- Land and forest management, Agro and bio diversity, Indo-China
- Capacity Development, joint post graduate research programs
- **Impact of adaptation to Climate Change on NDP. 4 country/8 studies**

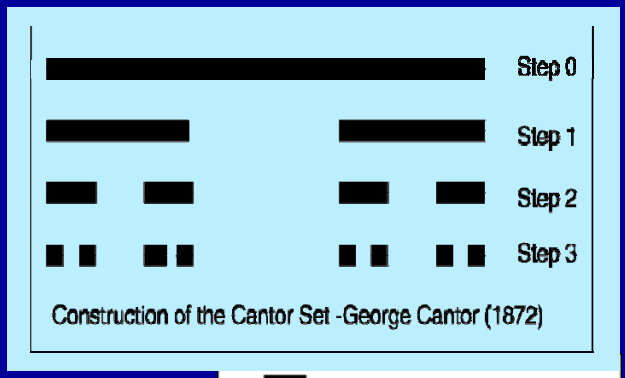
Early results and Challenges

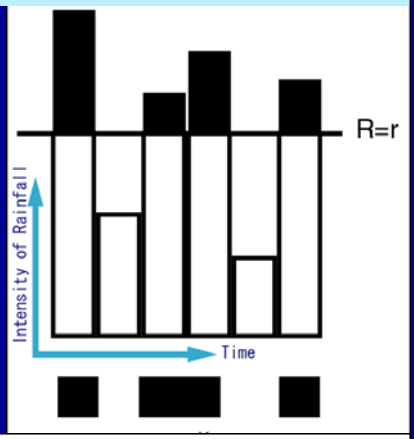
- Limitations to use physically based models:
  - Limitation of spatial data
  - Inadequacy of rainfall information
- Challenge
  - Is it possible to verify the basin water cycle?
- Need for basin wide collaboration and dialogue

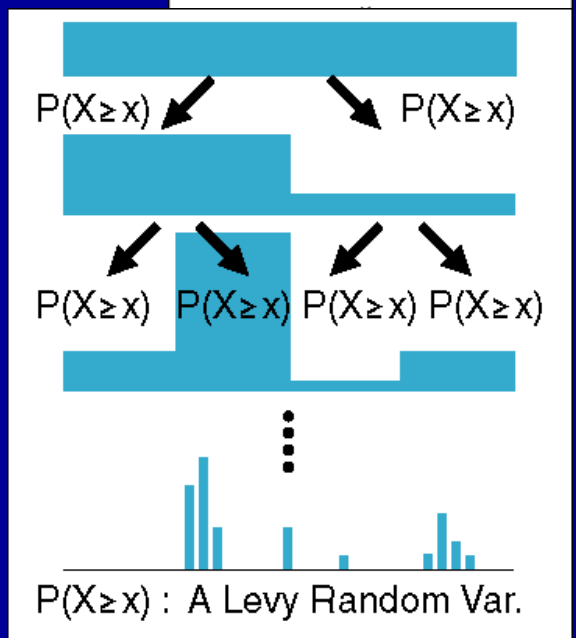
Lack of Long term Rainfall data for design purposes

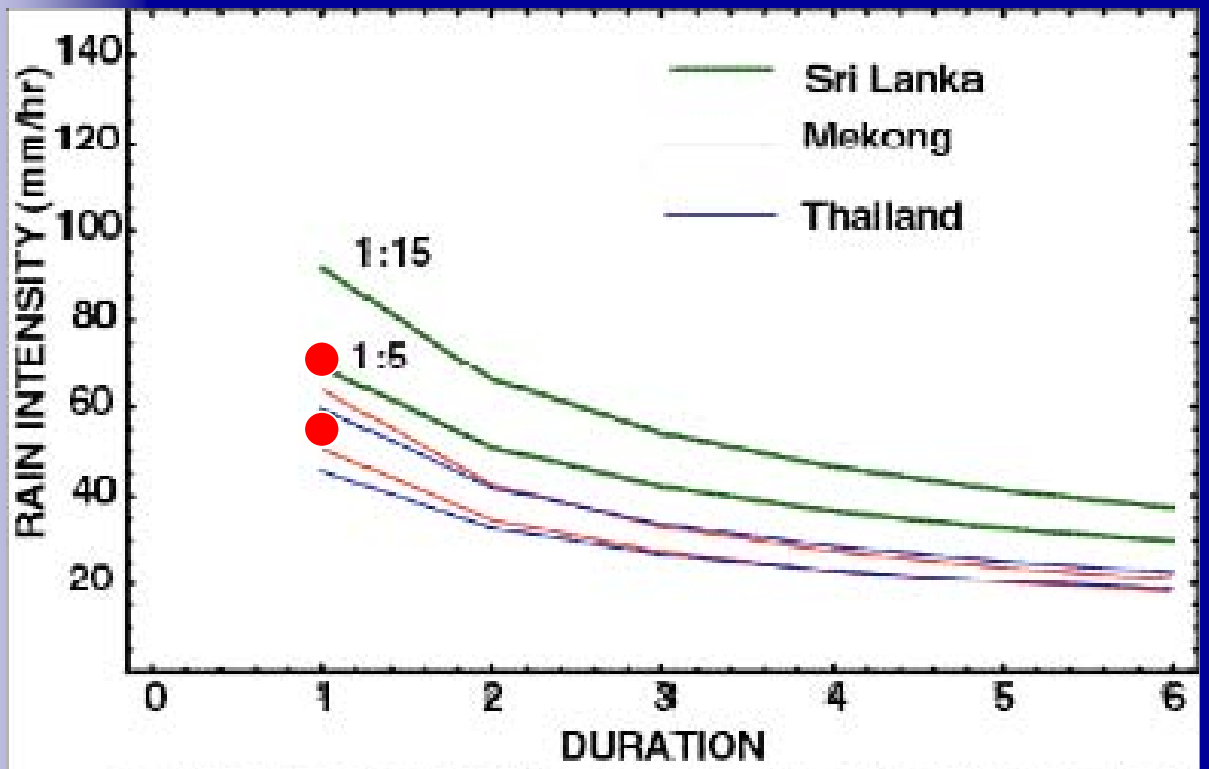
- How do we look at long term trends of rainfall intensity changes
  - Historical data not available for physical based models
  - Most of the long term data are available in coarse space and time resolutions
  - From Daily observations, it is necessary to estimate, hourly or sub-hourly values -> New methodologies:

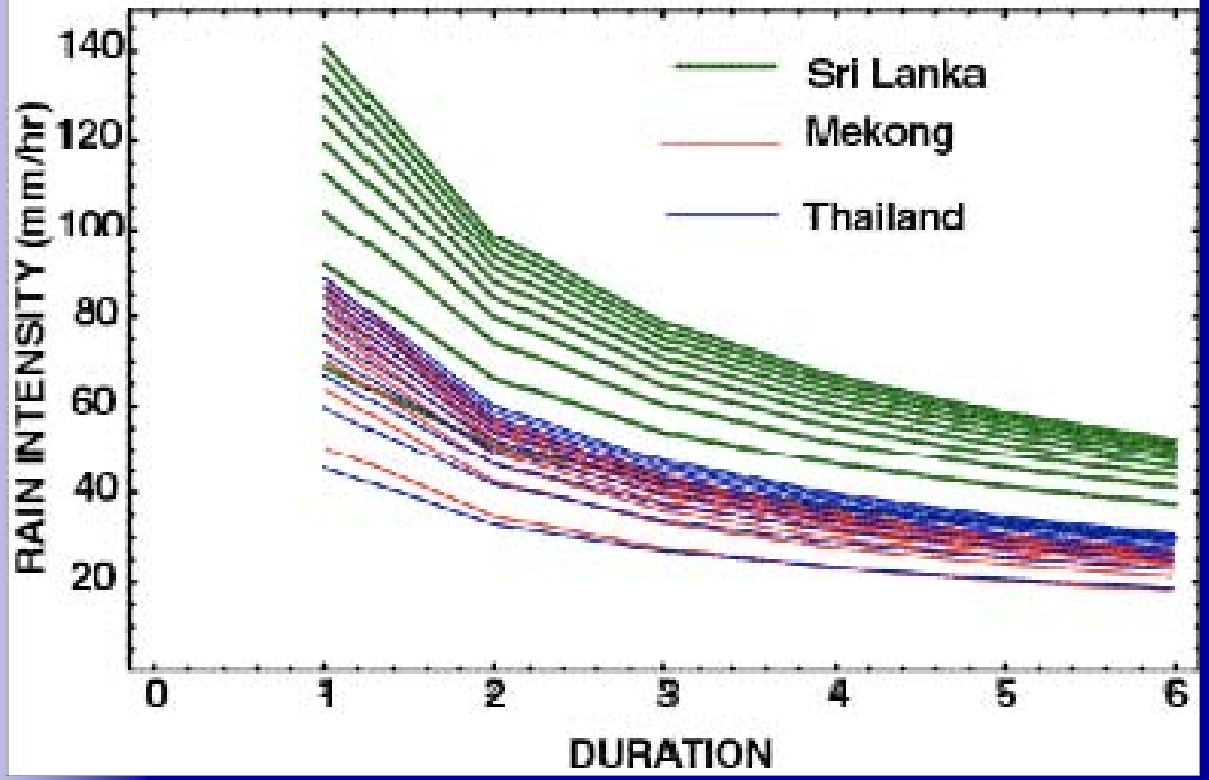
FRACTALS and
MULTI-FRACTALS







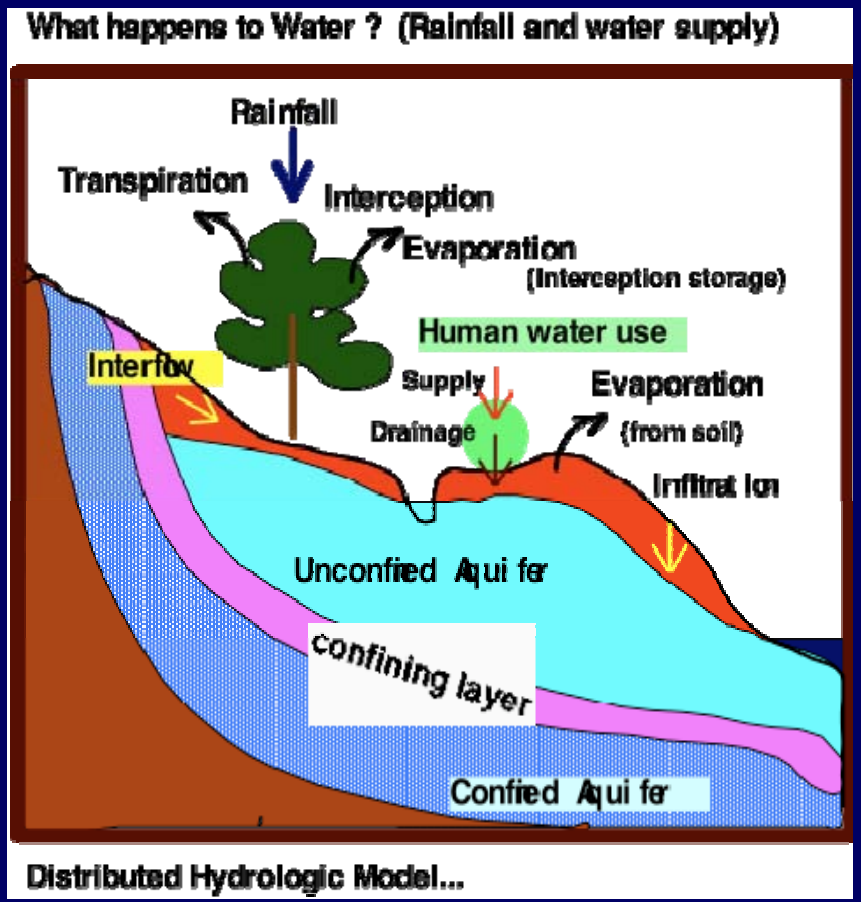


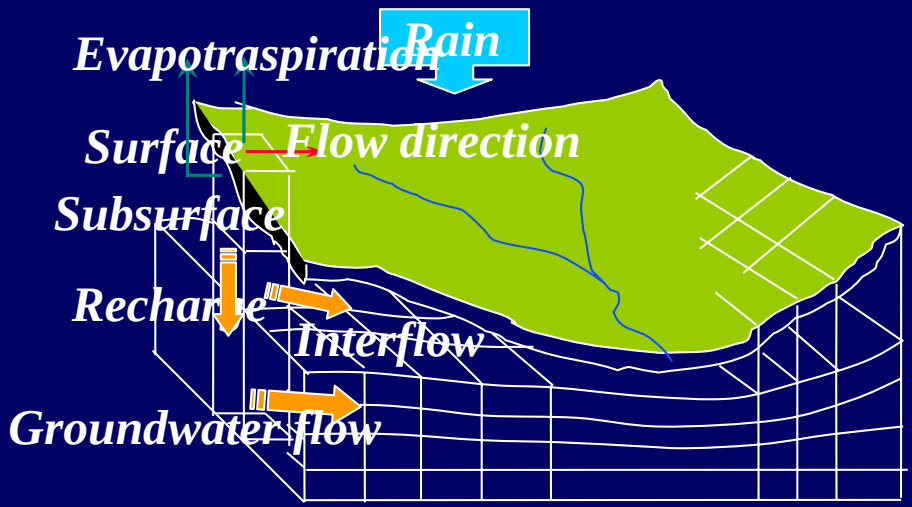


IDF Curves

- **Estimated IDF Curves for**
  - **Sri Lanka (Colombo)**
  - **Thailand (Chao Phraya basin)**
  - **Cambodia (Mekong Basin)**
  - **Shows promising values.**

Models and Predictions





- **Distributed uniform grid**
  - Pressure based
- **Slope-river network**
  - Storage <->pressure conversion
  - Storage<->moisture<->head

State Variable: Pressure or Storage

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Models and Data remarks

- It is almost impossible to clearly understand the water cycle of large basins - assessment of ground water flow, storage and transport remain a major challange
- Evaporation and water use, especially return flow characteristics may complement each other and using stream flows alone is not sufficient for verification
- Independent estimates of evaporation could be the key to clarify groundwater and water utilization patterns in large catchments
- For basin wide decision making, consensus on state of basin water cycle and its potential change is required.

Initiatives on Transboundary Issues

- UNU, in collaboration with AIT and Tammasat University, Thailand, organized **"The role of water sciences in Tran-boundary River Basin Management (TRBM)"** conference in March 2005 to promote upstream/downstream dialogue in the Mekong basin.
- As recommended by the participants an independent scientific body to promote joint research activities was formed and the first working group meeting was held in AIT, Thailand in July 2005.
- **International Symposium on Expanding Transboundary Cooperation for Water and Environment Security in Asia's International Rivers**, Dali, Yunnan Province, China, 10-15 December, 2005, organized in collaboration with the World Bank Institure,Tsinghua and the Yunan Universities, China.

March 2005, Thailand

December 2005, China

http://www.mekongnet.org

Main Page - MekongNet

http://www.mekongnet.org/Main_Page

Google

The United Nations University

Asian International Rivers Center, Yunan University

Institute of Meteorology and Hydrology, Vietnam

IIT-Roorkee, India

Tsinghua University

CSIRO, Austrialia

The World Bank Institute

Monash University

Washington University

Asian Institute of Techology

UNESCO-IHE

MekongBasinResearchNetwork

Main Page | Background | Activities | Mekong News | Resources World MekongNet | Resources UNU | Help | Discussion | Search

WELCOME to Mekong Basin Research Network (MekongNet) This activity is designed to provide science-based knowledge for cooperative/collaborative development and management of water resources in the Mekong River Basin through the creation of an international research network. The Mekong Basin Research Network provides knowledge and tools to assist policy making in the Mekong River Basin. This network addresses the issues relevant to the Sustainable Water Resources Management of the basin promoting basin-wide cooperation towards poverty alleviation ensuring environment security.

- Water Security
- Natural Disaster
- Eco-security

The research topics that are addressed are:

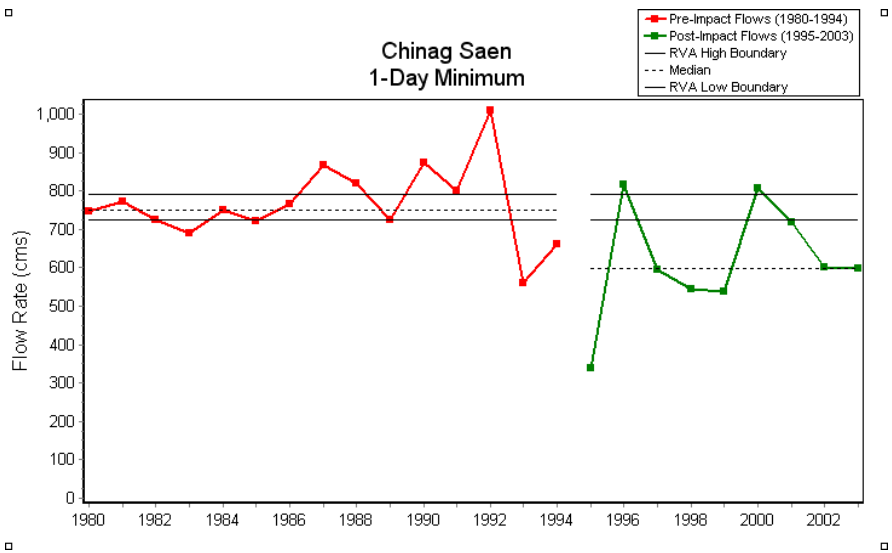
- ***Water security***: the sustainable utilization of water resources is vital to social, cultural and economic well being of the basin population. The program, therefore aims to maintain the health of the river through a strategy of monitoring, management and education

Some example studies within the frame work of network

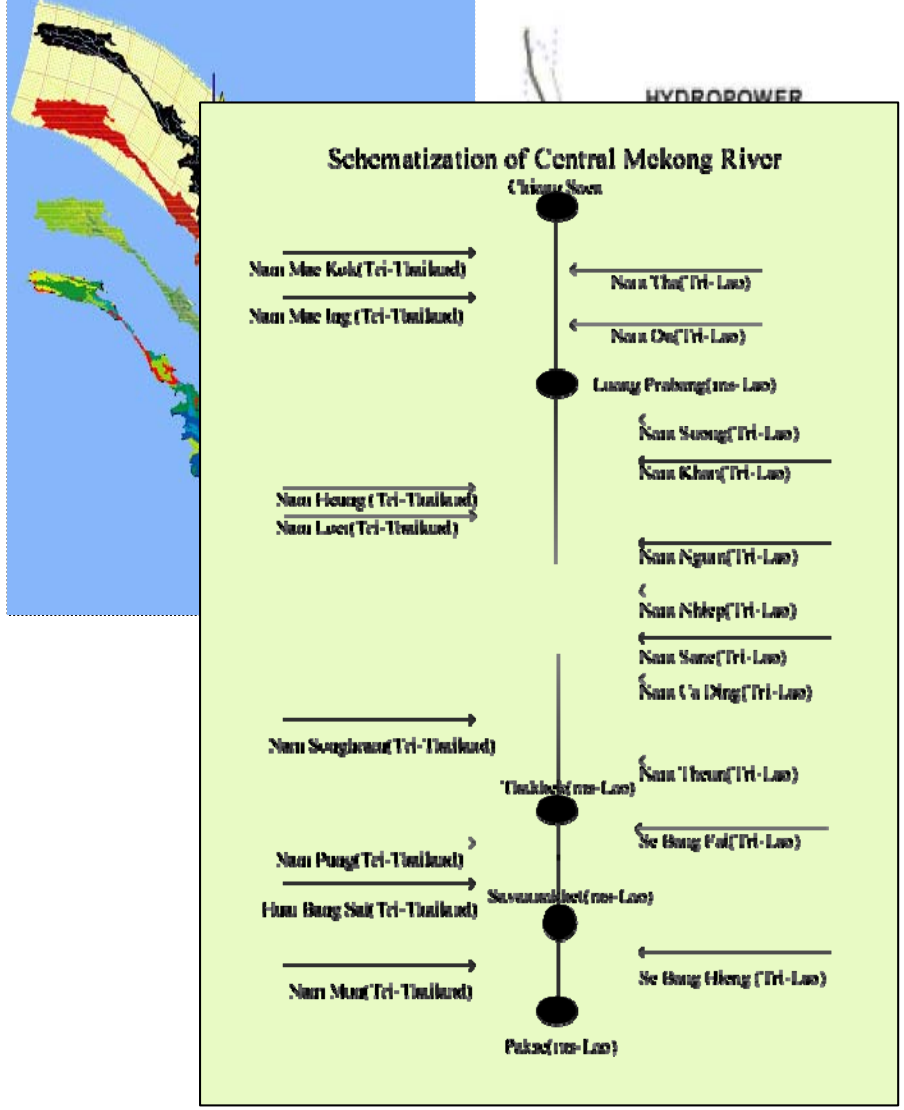
- Impact of upstream dam construction
- Water Poverty Index, Mekong Delta
- Water Scarcity: What is the limiting factor - water quantity or water infrastructure?
- Climate change impacts on rice production
- Sediment Transport: Prediction in large scale catchments - (verified in Thailand, applied in Mekong basin)
- Bank erosion (Lao) with Tammasart University
- Trade off between hydropower generation and maintaining river ecology (Viet Nam)

Range Variability Analysis

Magnitude (how much flow or what level?)
Duration (how long do certain flows or levels last?)
Timing (when do certain flows or levels occur?)
Frequency (how often do certain flows or levels occur?)
Rate of Change (how fast do flows or levels change from one condition to another?)



$$X_{Low} = X_{Median} - K*RVA$$
$$X_{High} = X_{Median} + K*RVA$$



1. **Hydrological alteration due to upstream dams**
2. **Impact of flow changes along the tributaries**

Water Poverty Index

$$WPI = \frac{w_r R + w_a A + w_u U + w_c C + w_e E}{w_r + w_a + w_u + w_c + w_e}$$

e condition that: $w_r + w_a + w_u + w_c + w_e = 1$

R = Water resources availability
A = Access to water
C = Capacity
U = Use of water
E = Environment

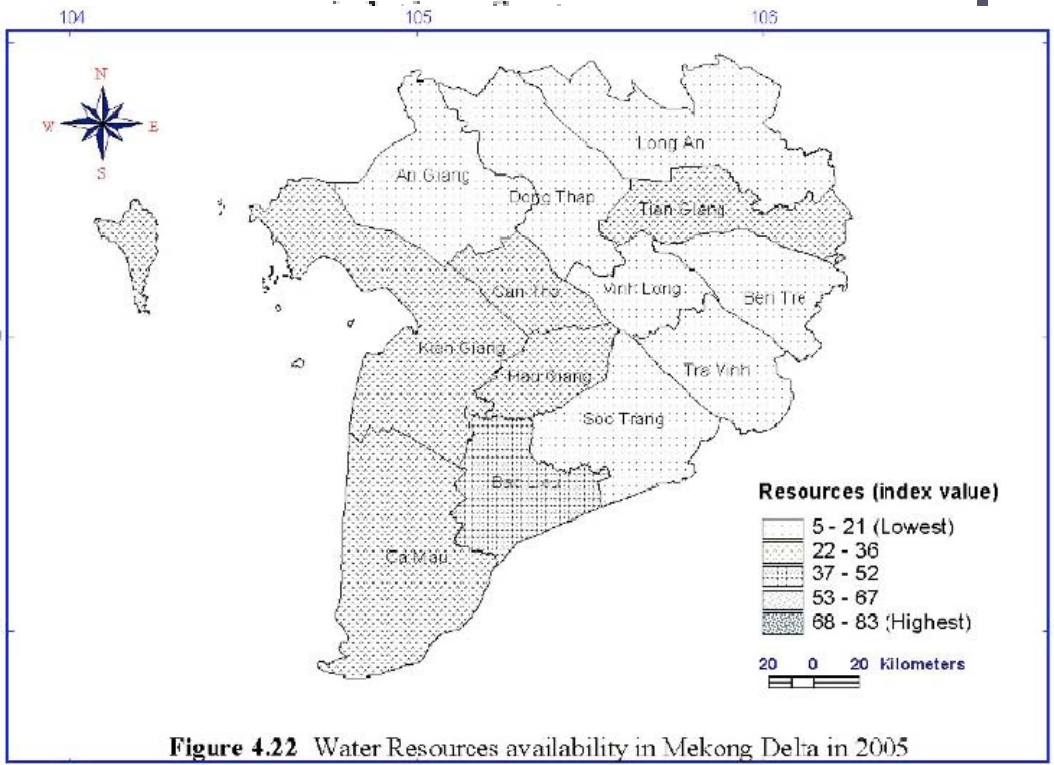
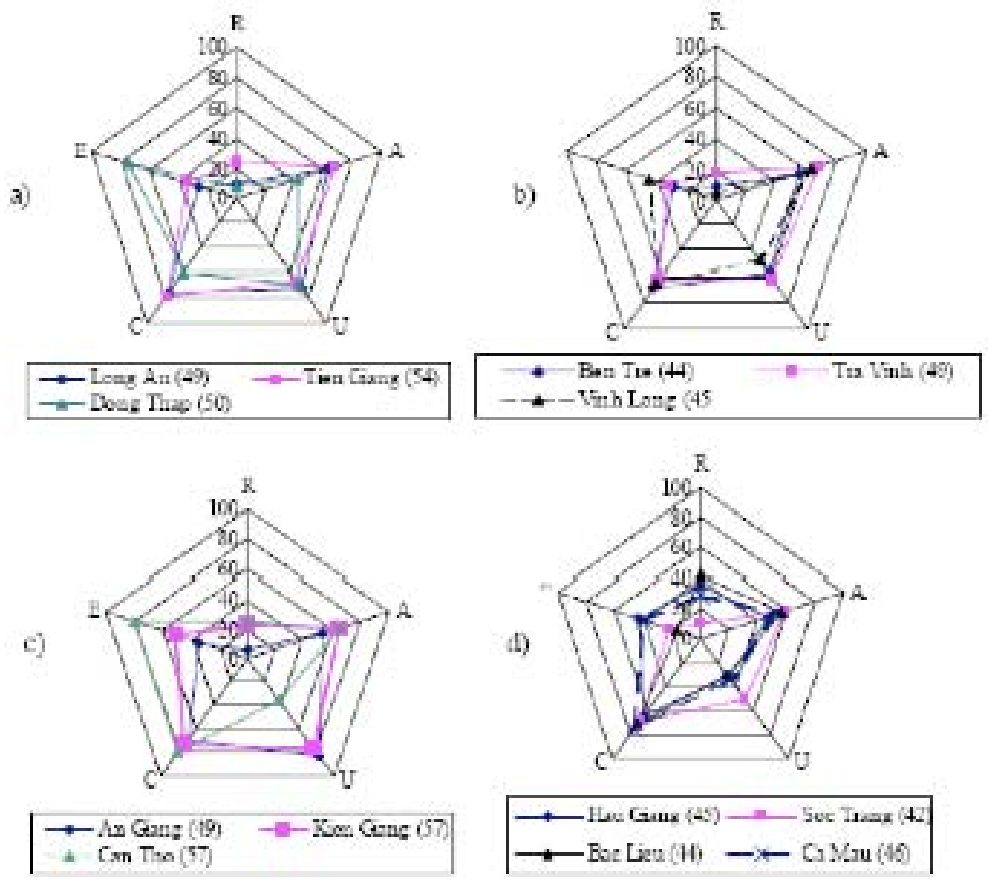


Figure 4.22 Water Resources availability in Mekong Delta in 2005



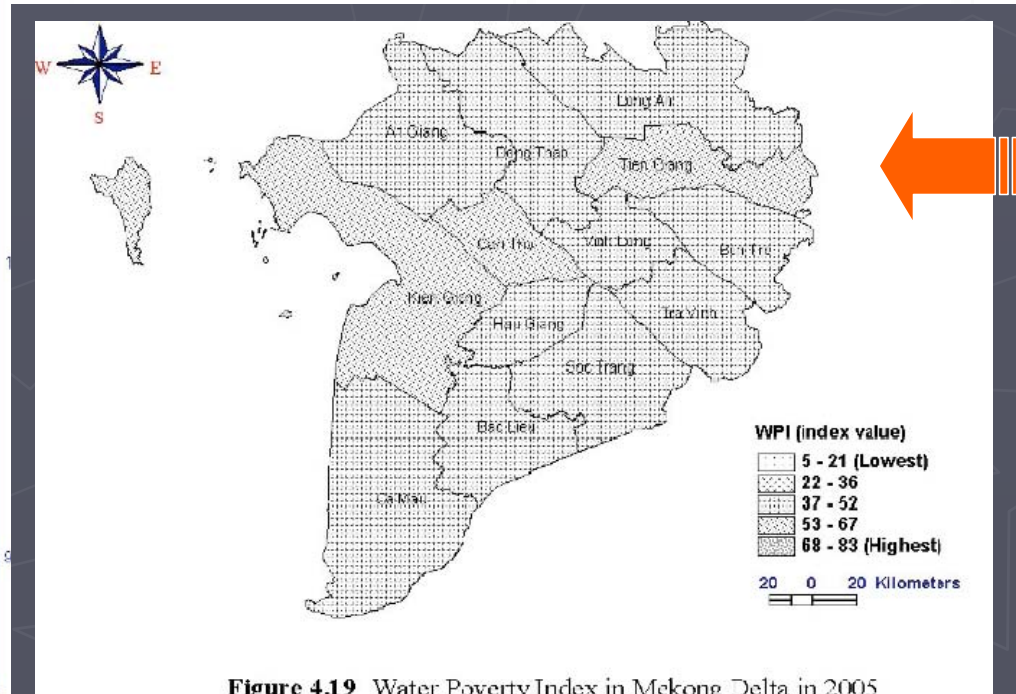
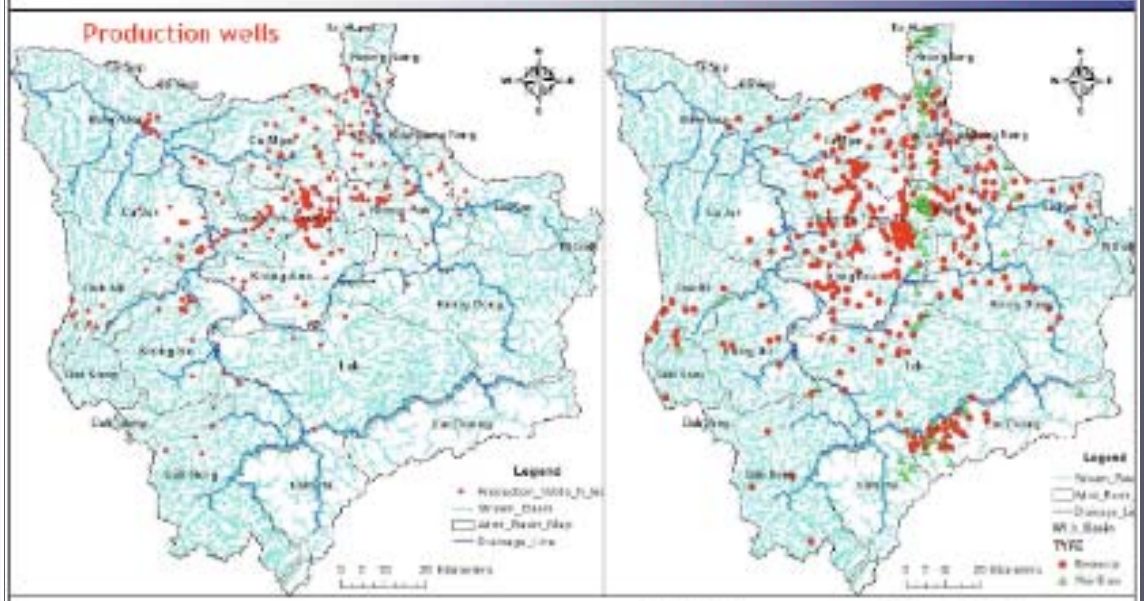


Figure 4.19 Water Poverty Index in Mekong Delta in 2005

BACKGROUND

WATER INFRASTRUCTURE INVENTORY



GW Infrastructures:
- No. of observation wells: 51
- No. of production wells: 408
- → Total safe discharge (l/s): 2,464

SW Infrastructures: (Total: 595) Details
- No. of reservoirs: 518
- No. of diversion weirs: 77
- Capacity of reservoirs (m3): 454,497,000
- Irrigated area (ha): 83,603

WATER SCARCITY INDICA

Summary of Annual and Seasonal Scarcity Level

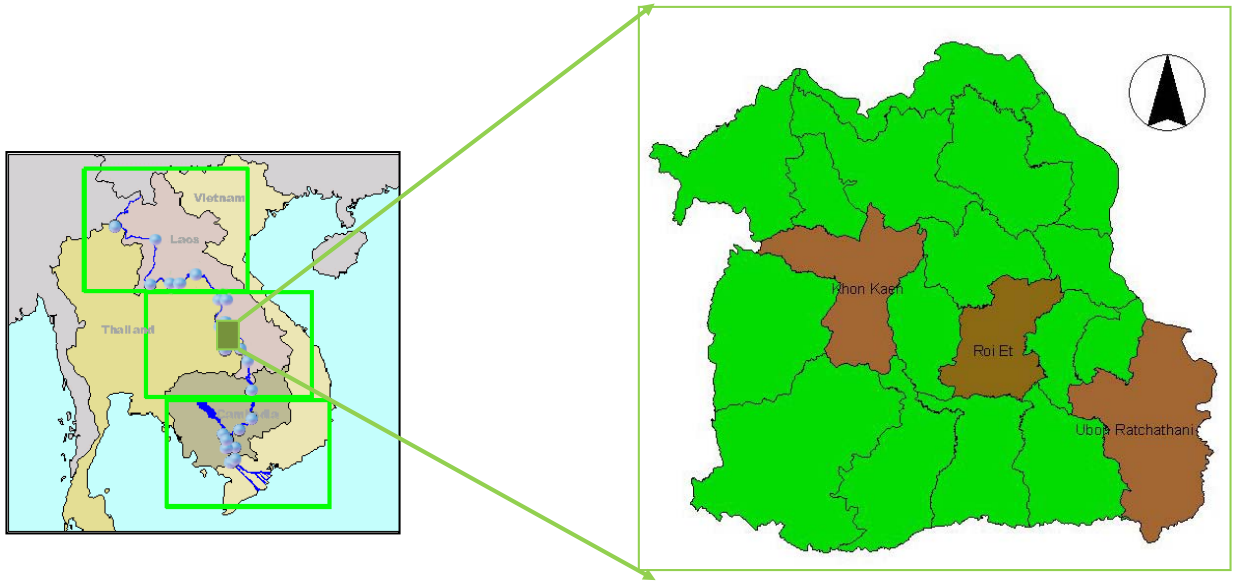
Level	Yearly basis			Seasonal Basis			
				UN		IWMI	
	Falkenmark	UN	IWMI	WET	DRY	WET	DRY
Basin							
2006	N	M		N	MS		
2010	N	MS	MS	M	S	MS	S
2020	N	S	S	MS	S	MS	S
District							
2006	1MS	1S		0S	8S		
2010	1MS	5S	4S + 12MS	3S	14S	3S + 15MS	13S + 6
2020	1MS	12S	6S + 12MS	5S	16S	4S + 15MS	15S + 5

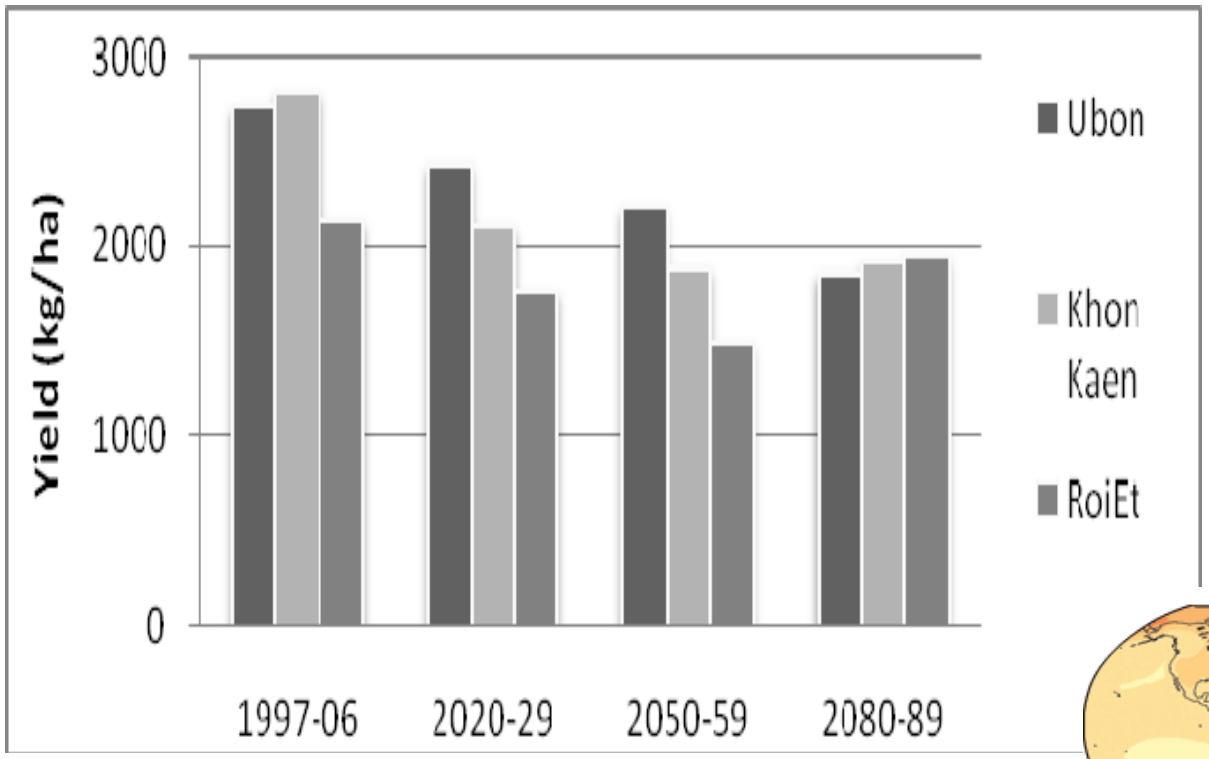
N: Little or no water scarcity; M: Moderate water scarcity; MS: Medium to severe water scarcity; S: Severe water scarcity.

IWMI criteria: MS → severe economic; M → Moderate economic scarcity.

CONCLUSIO

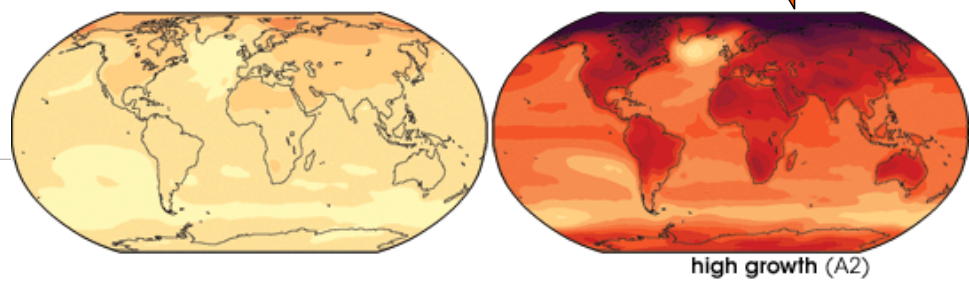
- Water availability (5,933m3/cap/day) → abundant compared to the country average (4,179); Thailand (3,344); South-East Asian (4,900); Asia (3,300) (Vietnam Environment Monitoring, 2003).
- Temporal and spatial variations of available water and demand → Water shortage still occurs in some districts during dry season → Constrain the future development of water resources (Agriculture).
- Water infrastructure → developed, but water withdrawal is still low (647m3/cap/year) compared to available resources → Significant investment in water infrastructure to increase future withdrawals is needed.
- Water scarcity: At basin scale → no serious scarcity at the present. Temporal and spatial variations of WA and WD → Most of districts will be in severe scarcity situation in both wet and dry season.





Data from Ubon Ratchathani, Khon Kaen and RoiEt provinces in Northeast region of Thailand was used to calibrate CERES-Rice crop growth model. Future climate scenarios for the period 2020-29, 2050-59 and 2080-89 indicated that there will be a reduction in the rice yield by about 18, 28 and 24% in the region during 2020s, 2050s and 2080s, respectively, compared to the average yield of years 1997-2006.

CO2 fertilization offset by high min. temperature



Integrating Research, Capacity Development and Applications

National training programs for researchers and practitioners

Supporting Post graduate Reserach

Field Stations
Pilot Project

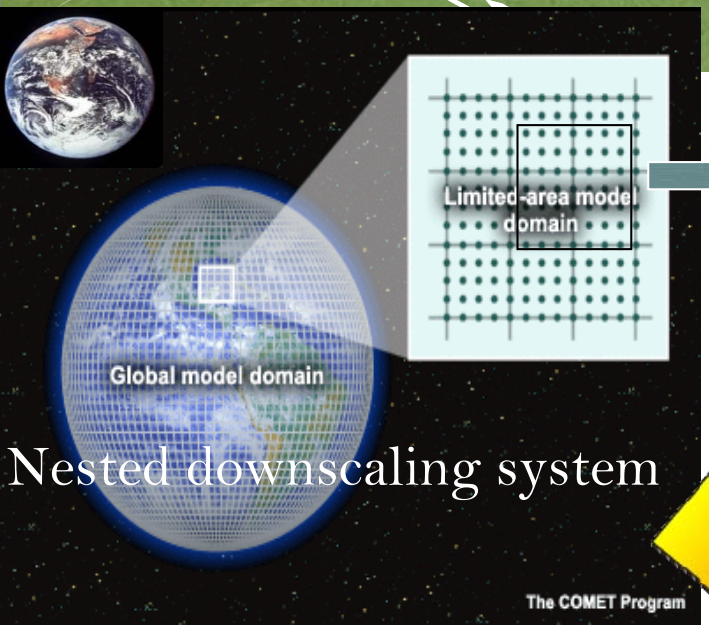
Training of trainers
higher education and implementing agencies

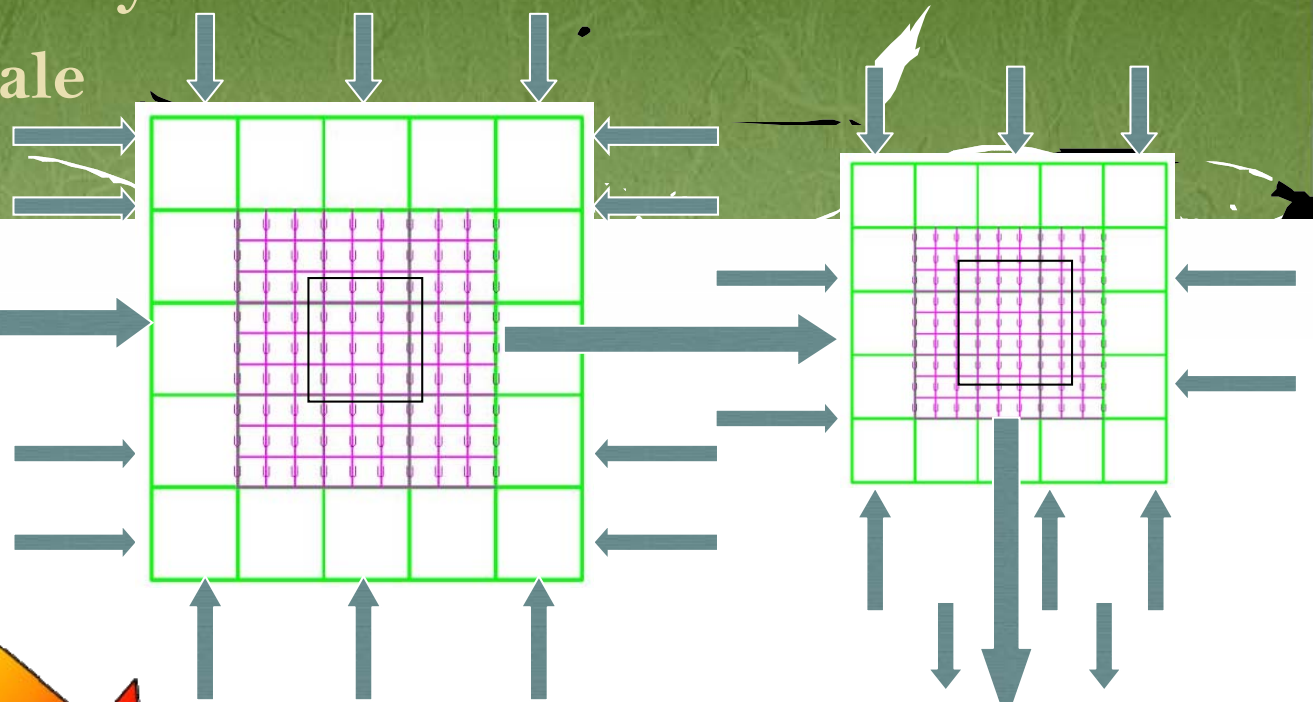
Dissemination of results to policy makers

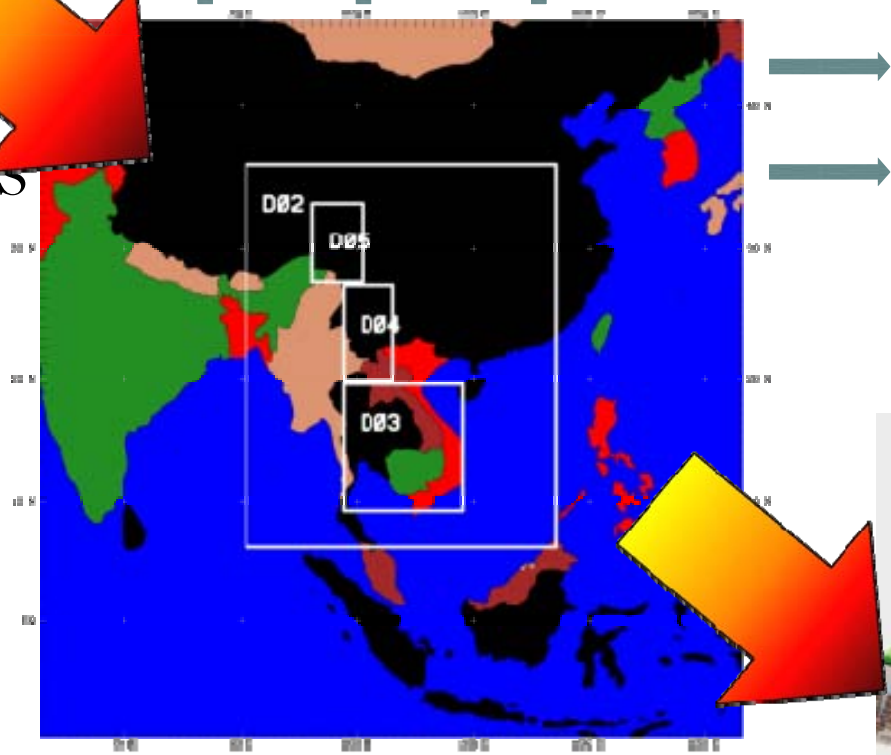
UNU example project

- A number of catastrophic floods or near misses highlighted the danger of catastrophic disasters striking a major urban center.
- UNU convened an expert meeting in 2003 from 15 countries in Asia Pacific
  - Bangladesh, Cambodia, China, Fiji, India, Indonesia, Lao PDR, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam
- which recommended a joint action programme, focusing on assessing extreme flood risks and developing response plans
- Building on case studies a training program comprising of 3 modules rainfall downscaling, GIS and inundation modeling have been developed.
- Training trainers --> Country training --> Post grad research

①Downscaling with Physically based models
②Global to Watershed scale

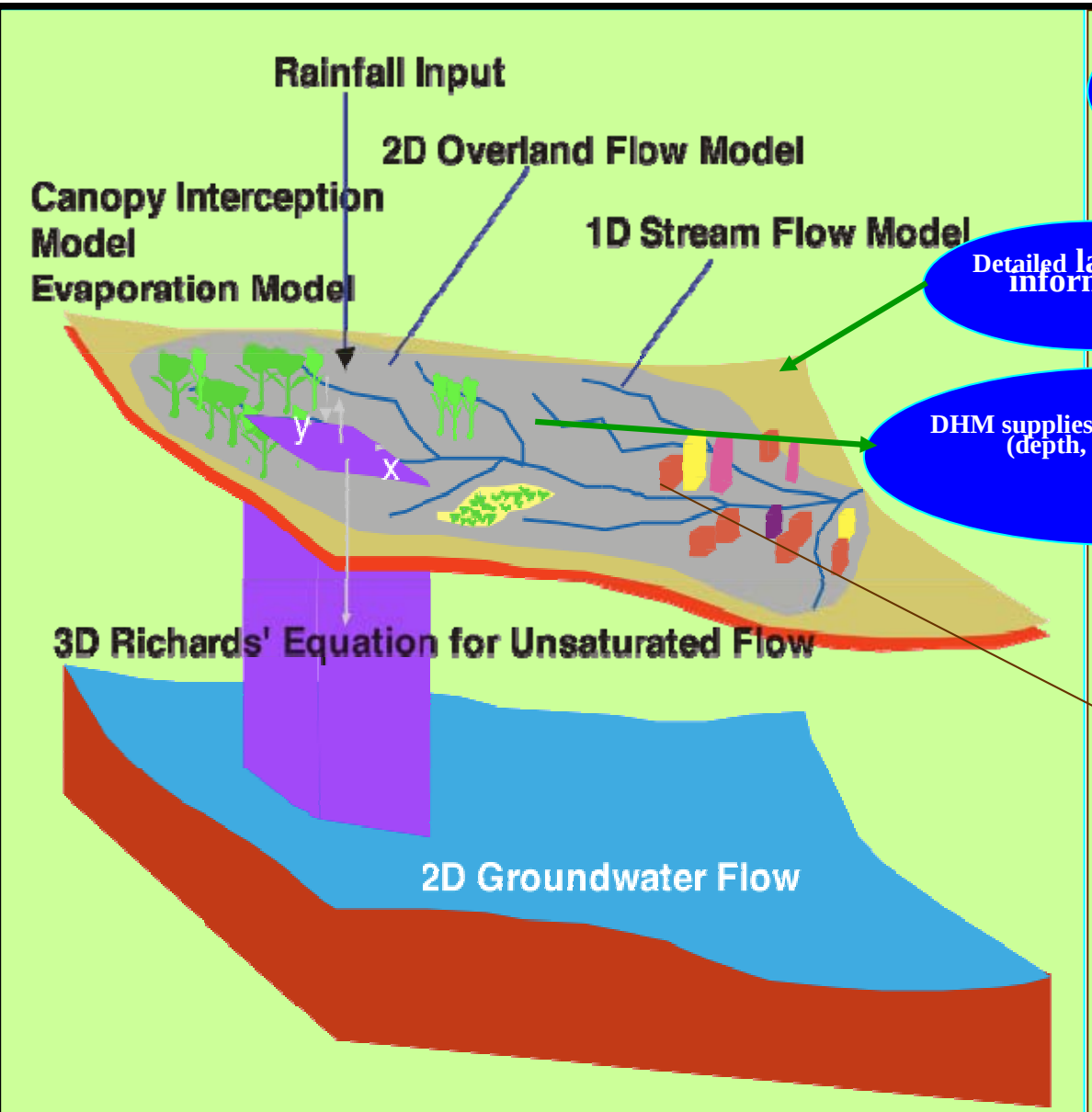






- We use the global forecast (GFS data sets)
- Weather Research and Forecasting (WRF) Model of NCAR, USA used for downscaling
- Use for scenario modelling and forecasting

Inundation Modeling & Damage Assessment



Questionnaire survey & historical data

Damage Classification

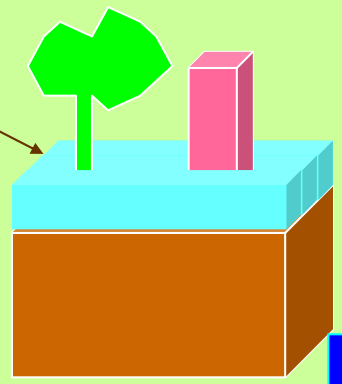
Development of fragility (or stage-damage) functions

Detailed landcover information

Establish damage estimation model for each type of object

DHM supplies: Flood data on each grid (depth, duration, velocity)

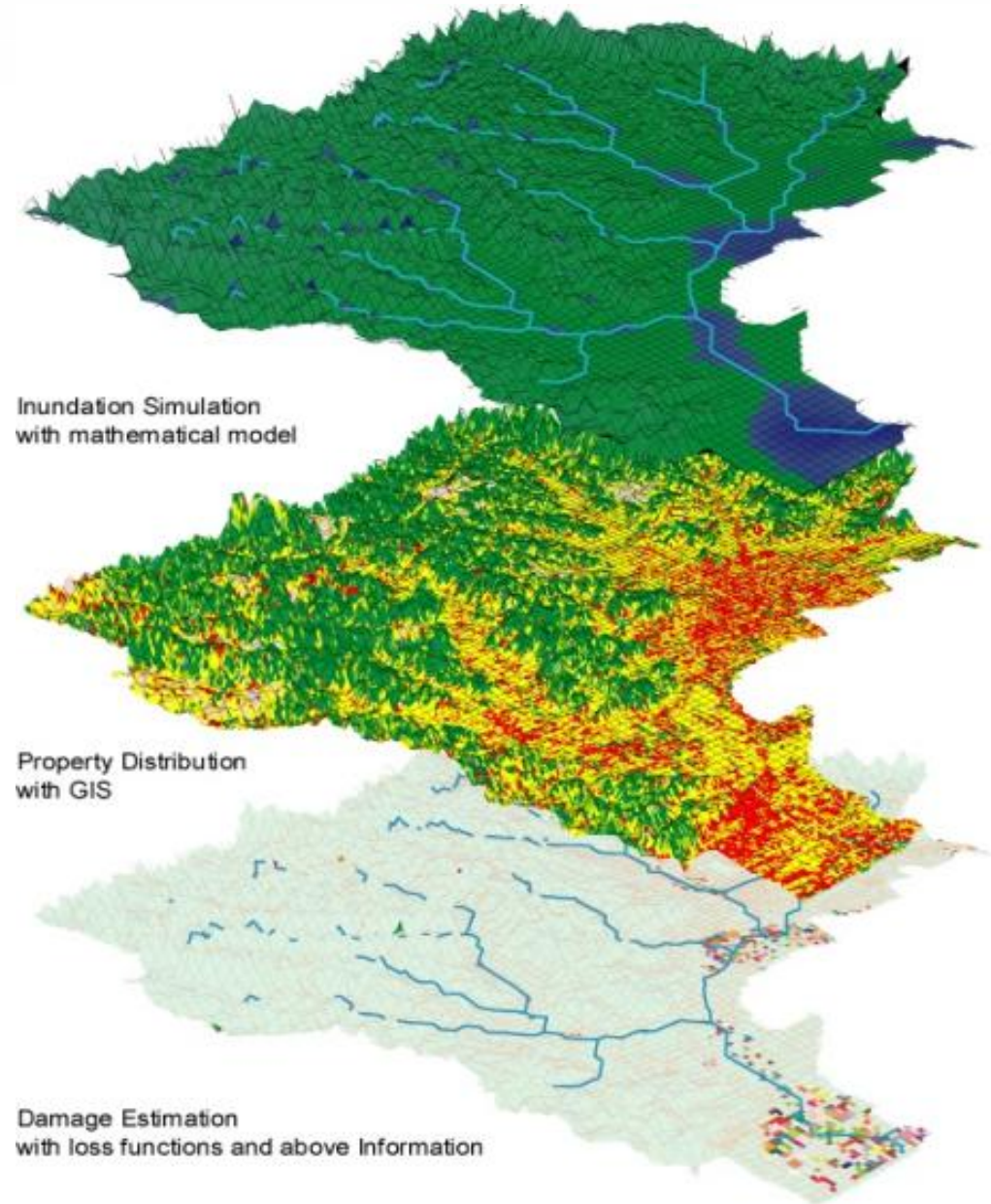
Flood Damage Estimation in each grids using established models for each type of damage.



Output: estimated distributed flood damage

Damage Estimation Model

Flood Inundation: Simulated/Measured

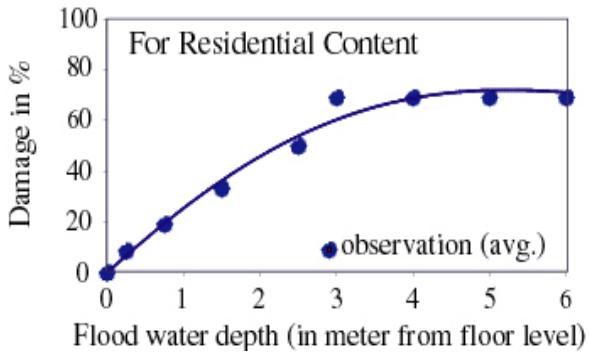


2 resident categories

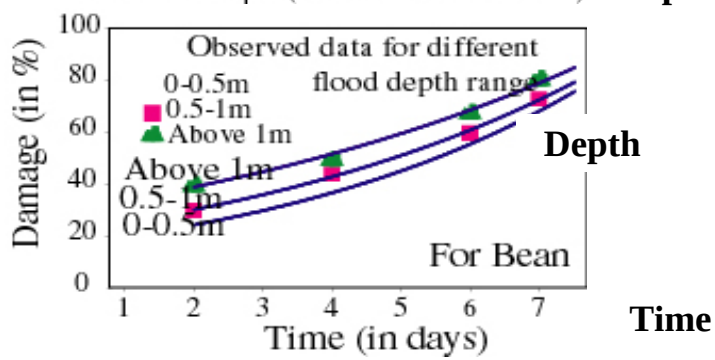
10 business/industry categories

8 categories of agriculture products

Property Distribution



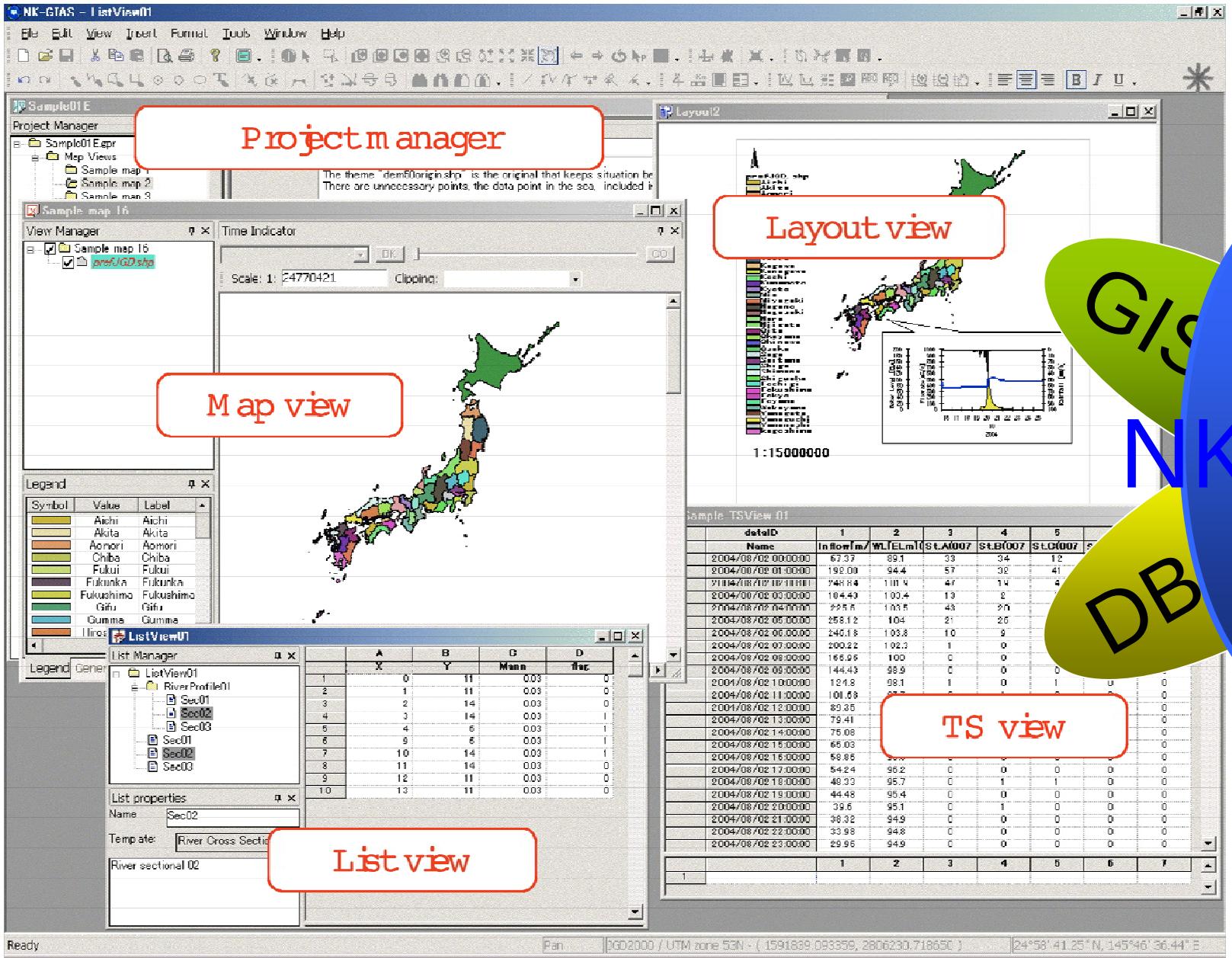
Residential building content



Beans

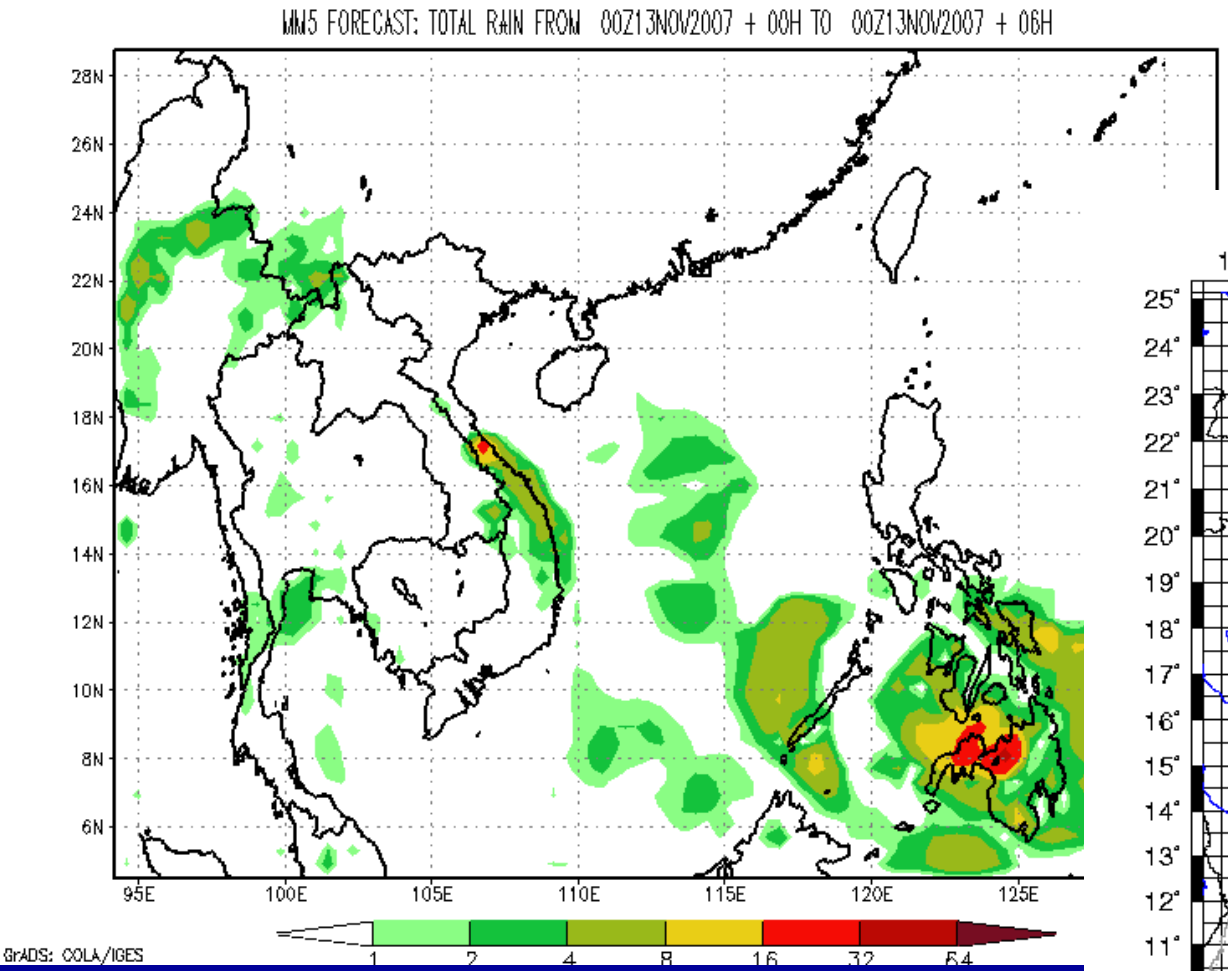
Economic damage Distribution

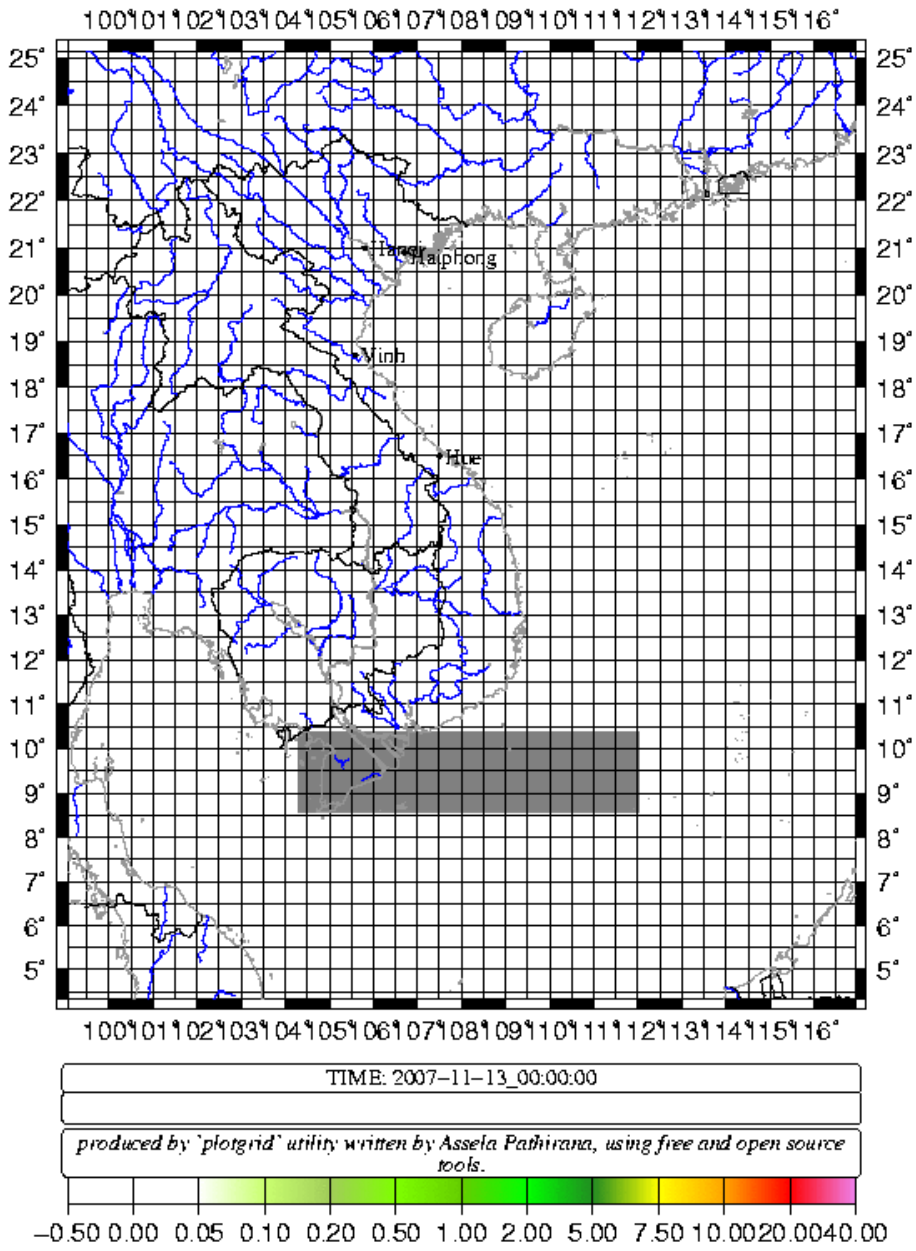
GIS system


NK-GIAS – ListView01
Project Manager
Project manager
Layout view
Map view
TS view
List view
Five windows.
NK-GIAS

Phase I & II

- 2007-2008, 5 countries phase 1 and 2 completed
- 2009-2010, another 5 countries will start
- Faculty from Universities and Senior professional from a responsible organization



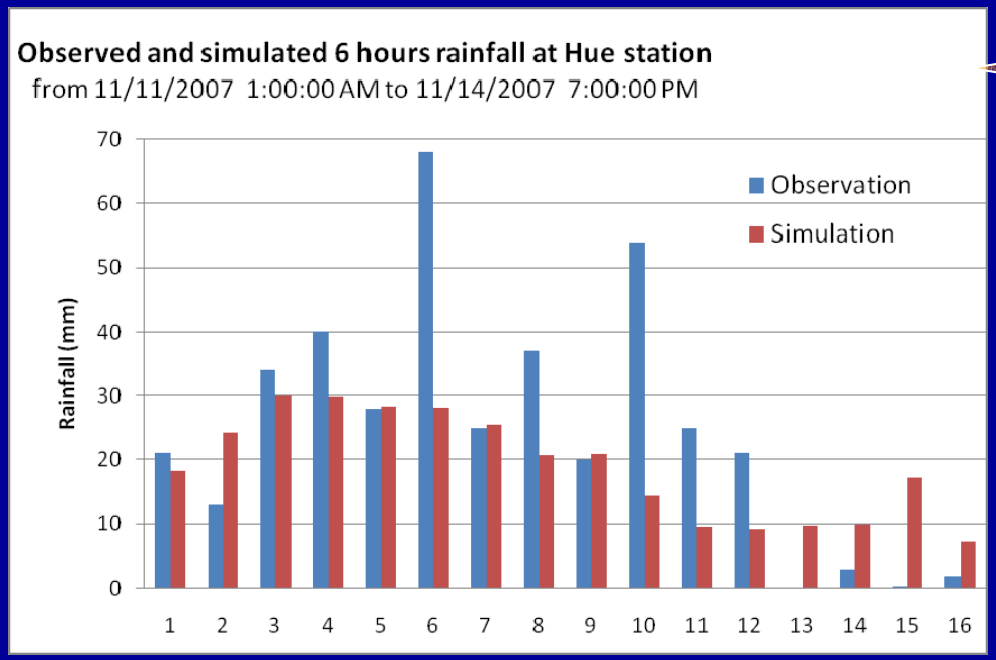


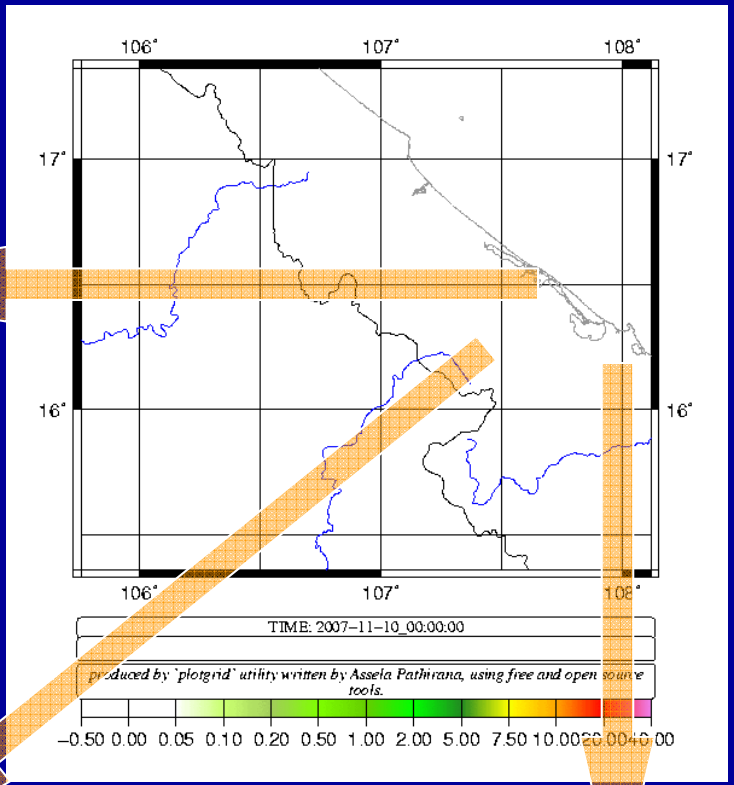
Forecast Result for 13 Nov 2007

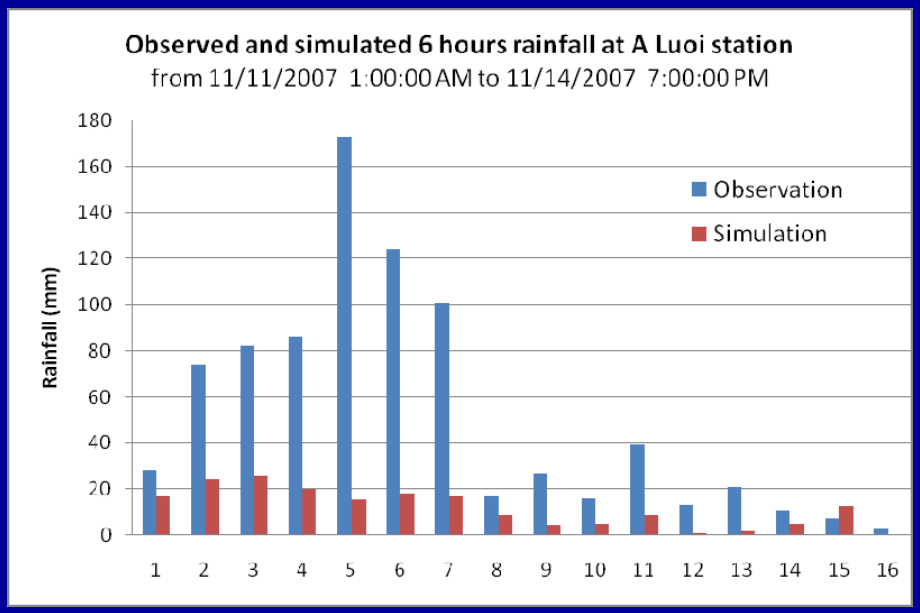
Comparison Observed Rainfall and Forecast Result from WRF - 13 Nov 2007

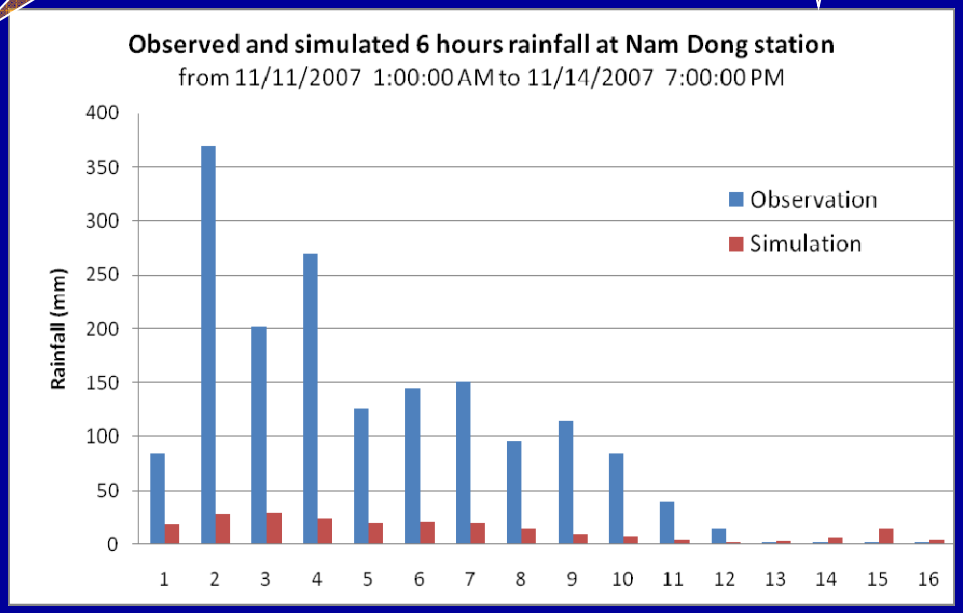
Station	Observed rainfall		Forecast result from WRF	
Hue	79	21	42.4	26.73
A Luoi	5.5	3.4	13.6	10.7
Pleiku	0	0	8.58	8.55
Tam Ky	5.0	29.5	12.7	12.2
Da Nang	11.5	10	15.8	14.6
Dong Hoi	4.1	1	0.21	0.2

- Time of simulation : 2007 NOV 11 – 14
- Grid spacing : 45-15-5km for domain 1-2-3
- Meteorological data: Every 6h from NCAR
- Time step : 270s



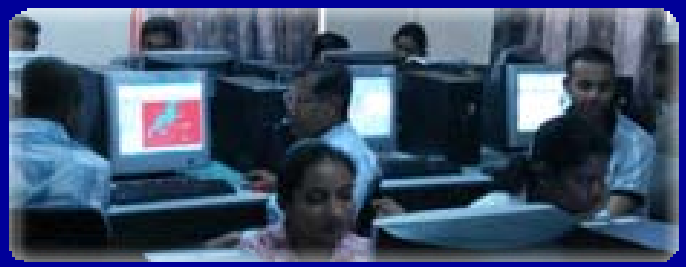






Participants

Organization		Participants
Irrigation Department	7	DD, 3 Chief Eng, 3 Eng
MASL	11	RPM, 2 CE, 7 Eng
University	5	2 Senior Lectures, 2 Lecturers, 1 Post Grad
CECB	6	DGM, AGM, 2 PM, 2 Eng
Disaster Management	1	DD
Met Department	1	Meterologist
Survey Dept	1	Cartography Unit
Lanka Hydraulics	2	Eng. Manager, Engineer
Lowlying development	1	Engineer
	35	

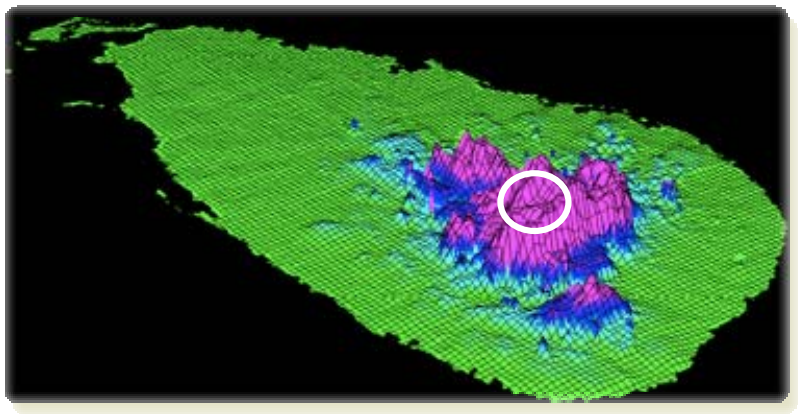


National Capacity Development Workshops (ex. Viet Nam, Aug, 2009)

Number of Participants 30 from:
National Center for Hydro-Meteorological Forecasting, The Central Committee for Flood and Storm Control, Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN)
Hanoi Water Resources Unversity, etc.

QuickTime™ and a decompressor are needed to see this picture.

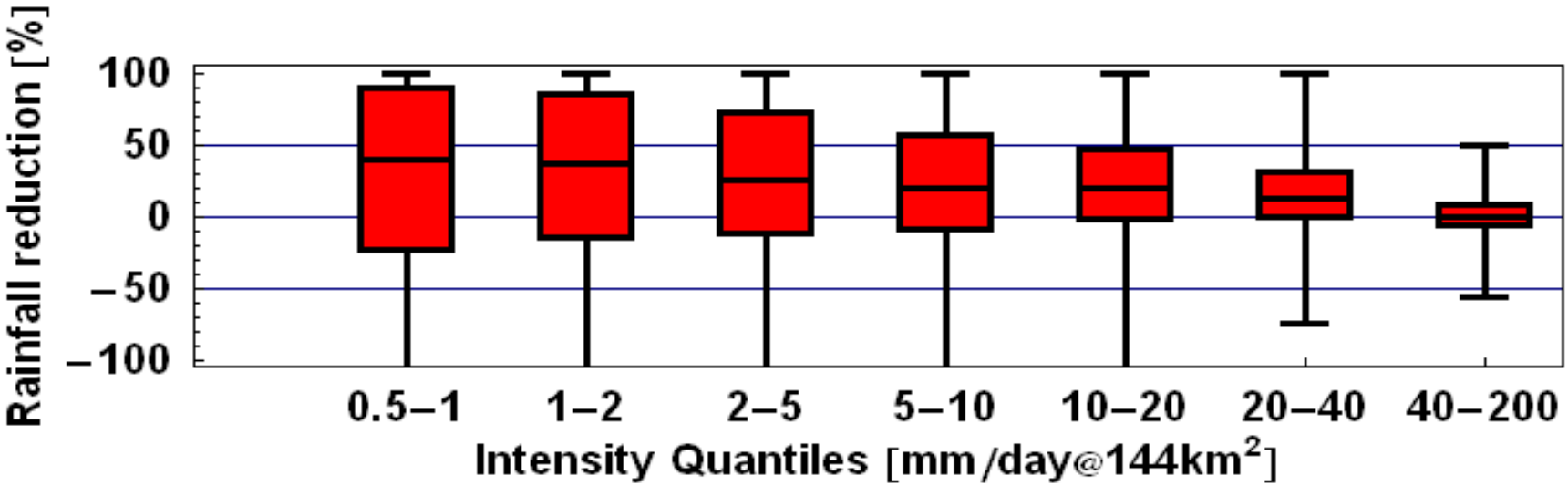
Case study on impact of 'Global Dimming' Central Sri Lanka – Kotmale Basin



- Observations
  - Tea plantation managers and farmers: Climate has changed
  - Change to seasons
  - Drizzle has disappeared. Intensity has increased
- Activities
  - Installation of high resolution rain gauge network
  - A fractal modeling study that showed increasing rain intensities
- Findings
  - Number of high intensity Rain events increased
  - Inter-monsoon (March to April) decreased

Results of a six months period simulation over southern part of Sri Lanka.

Result 2: Reduction of Rainfall



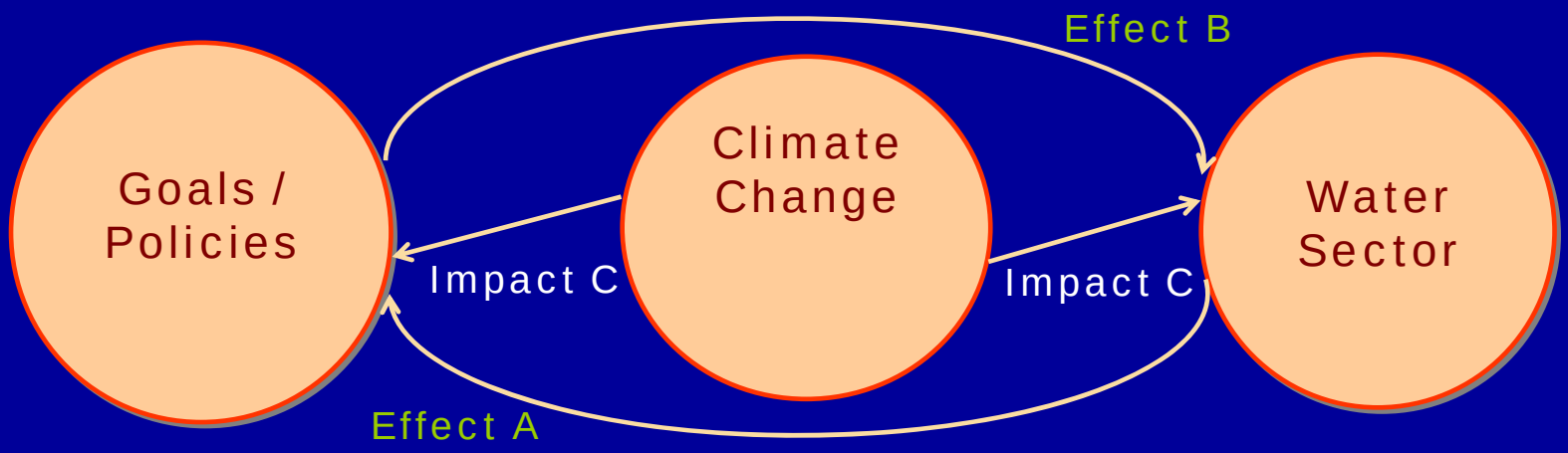
- For large rainfalls the % effect is small (for 100mm/day ~ 4%)
- For small rainfalls % effect is large (for 1-2mm/day ~ 40%)

Action Impact Matrix to Prioritize Policies considering economic, environmental and social aspects.

- Two types of matrix

  - Water Using Sectors Vulnerability, Impacts and Adaptation and effects on development (WED)
  - Development Effects on Water Using Sectors Vulnerability, Impacts and Adaptation (DEW)

- WED-AIM = Effect A + Impact C
- DEW-AIM = Effect B + Impact C



AIM study carried out by MIND (Prof. Mohan Munasinghe)

Example of AIM

< sample of WED-AIM >

Water using sectors

		Vulnerability, Impacts & Adaptation (VIA) in Water Using Sectors				
		(1)	(2)	(3)	(4)	
		Agriculture	Hydro Power	Water for Humans (Esp. Poor)	Water for Bio- & Eco-logical Res.	Row Totals (With CC)
(S0)	Status (No CC impacts)*	-1	0	-1	-1	-3
(S1)	Status (+CC Impacts =>)**	-2	-1	-3	-2	-8
=> Dev. Goals/Policies (+CC Impacts)						
(A)	Growth	-2	-1	-3	-2	-8
(B)	Poverty alleviation	-3	-1	-3	-1	-8
(C)	Food Security	-2	-1	0	-1	-4
(D)	Employment	-2	0	-1	-1	-4
(E)	Trade & Globalisation	-1	-1	0	-1	-3
(F)	Budget Deficit Reduction	-1	-1	-1	-1	-4
(G)	Privatisation	0	0	0	-1	-1
Column Totals (With CC)		-11	-5	-8	-8	-26

- How development goals will affect water using sectors?

< sample of DEW-AIM >

Development Goals

		Vulnerability, Impacts & Adaptation (VIA) in Water Using Sectors				
		(1)	(2)	(3)	(4)	
		Agriculture	Hydro Power	Water for Humans (Esp. Poor)	Water for Bio- & Eco-logical Res.	Row Totals (With CC)
Dev. Goals/Policies (No CC Impacts) =>						
(A)	Growth	0	1	1	0	2
(B)	Poverty alleviation	0	-1	-1	0	-2
(C)	Food Security	-1	-1	-1	0	-3
(D)	Employment	1	0	0	1	2
(E)	Trade & Globalisation	1	1	0	-1	1
(F)	Budget Deficit Reduction	-1	-1	-1	-1	-4
(G)	Privatisation	0	1	-2	-2	-3
Column Totals (No CC)		0	0	-4	-3	-7
(S1)	Status (+CC Impacts =>)**	-2	-1	-3	-2	-8
Column Totals (With CC)		-2	-1	-7	-5	-15

- **How water using sectors will affect Development goals?**

Study Conducted with MIND (Munasinghe Institute for Development

Effect of water using sectors on Development

		Vulnerability, Impacts & Adaptation (VIA) in Water Using Sectors				
		(1)	(2)	(3)	(4)	
		Agriculture	Hydro Power	Water for Humans (Esp. Poor)	Water for Bio- & Eco-logical Res.	Row Totals (With CC)
(S0)	Status (No CC impacts)*	-1	0	-1	-1	
(S1)	Status (+CC Impacts =>)**	-2	-1	-2	-2	
=> Dev. Goals/Policies (+CC Impacts)						
(A)	Growth	-3	-1	-2	-2	-8
(B)	Poverty Alleviation	-2	-1	-3	-1	-7
(C)	Food Security	-3	-1	0	-1	-5
(D)	Employment	-2	0	-1	-1	-4
(E)	Trade & Globalisation	-1	-1	0	-1	-3
(F)	Budget Deficit Reduction	-1	-1	-1	-1	-4
(G)	Privatisation	0	0	0	-1	-1
Column Totals (With CC)		-12	-5	-5	-7	

* Row (S0) is used ONLY as the baseline to estimate Row (S1).

** Row (S1) is used to estimate impacts on goals/policies in the matrix cells below it

Water using VIA areas that are most harmed

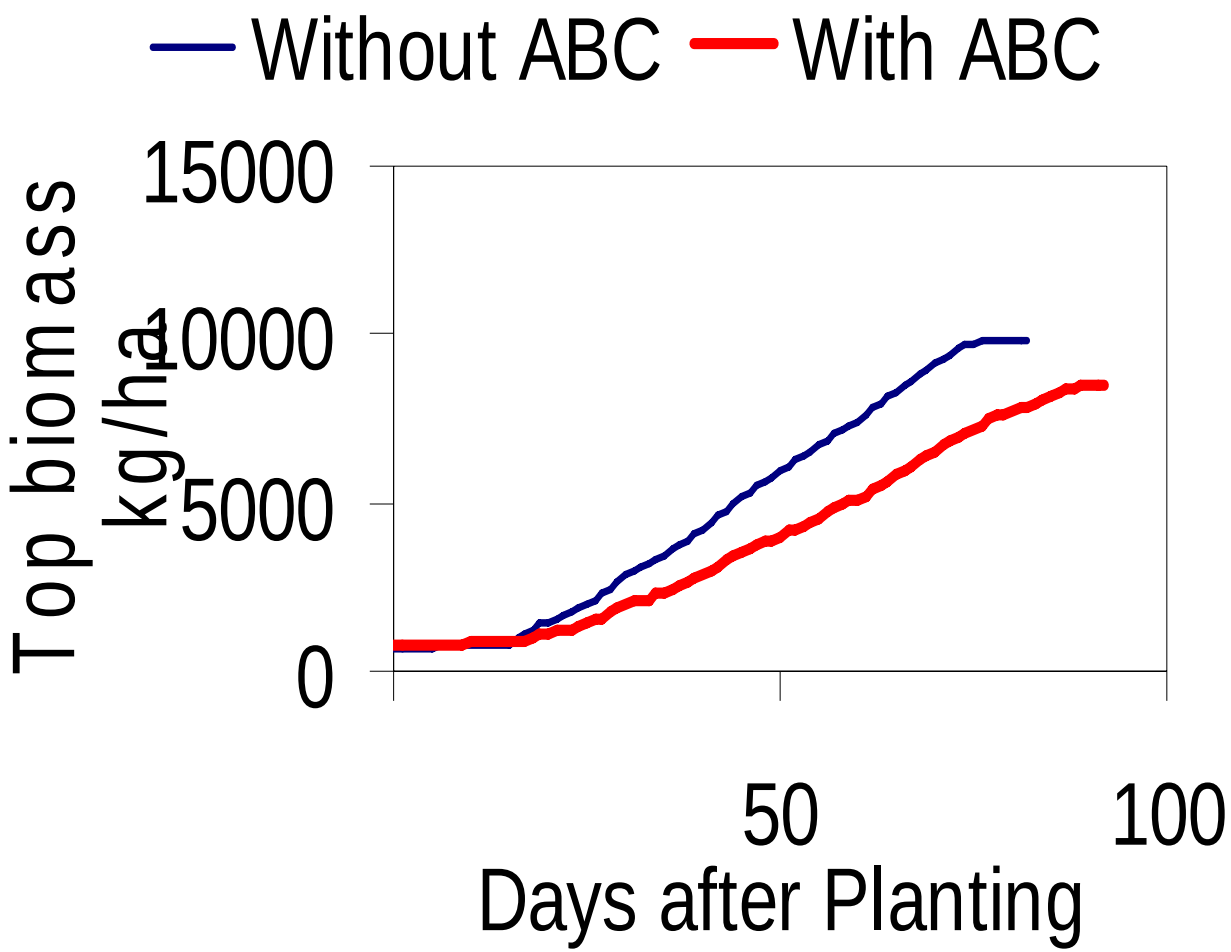
Development Goals/Policies that are most damaging

Key matrix cells that need policy interventions

NOTES:
Water for Humans (Esp. Poor) => drinking, health, livelihood, etc.
Water for Bio- & Eco-logical Res. => forests, wetlands, coastal zones, biodiv., etc.

Risks: In a predominantly small holder system, agriculture is the finest instrument for PA. Disturbance of rainfall patterns adversely affect the rainfed and Chena farmers, the poorest among the farming community. Loss of crops due to floods and droughts saps the farmers of the meager savings and leads them to abject poverty.

Yield Change due to ABC



- **"Maha" (October – March) season rice yield reduces from 5573 kg/ha to 4599 kg/ha [17% reduction]**
- **Studies in India – 15% reduction (Ramanathan et. Al)**

Need different rice varieties, water management facilities and other supporting policies to overcome this deficit.

University network for Climate and Ecosystems Adaptation Research (UN-CECAR)

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UNU-ISP News

Climate Change

The Role of Higher Education in Adapting to Climate Change

Speakers on the first day of the conference (from left, first row): S. B. S. Abayakoon, Konrad Osterwalder, Isao Kiso, (second row) Janette Lindesay, Diqiang Li, Nobuo Mimura, Toshio Koike, (third row) Kazuhiko Takeuchi, Kazushige Taniguchi, Hiroyuki

UNU-ISP, which became operational on 1 January 2009, was established to exploit the strengths of the former UNU Environment and Sustainable Development and UNU Peace and Governance Programmes, and to create transdisciplinary sy[illegible] global problems of human survival, development and welfare.

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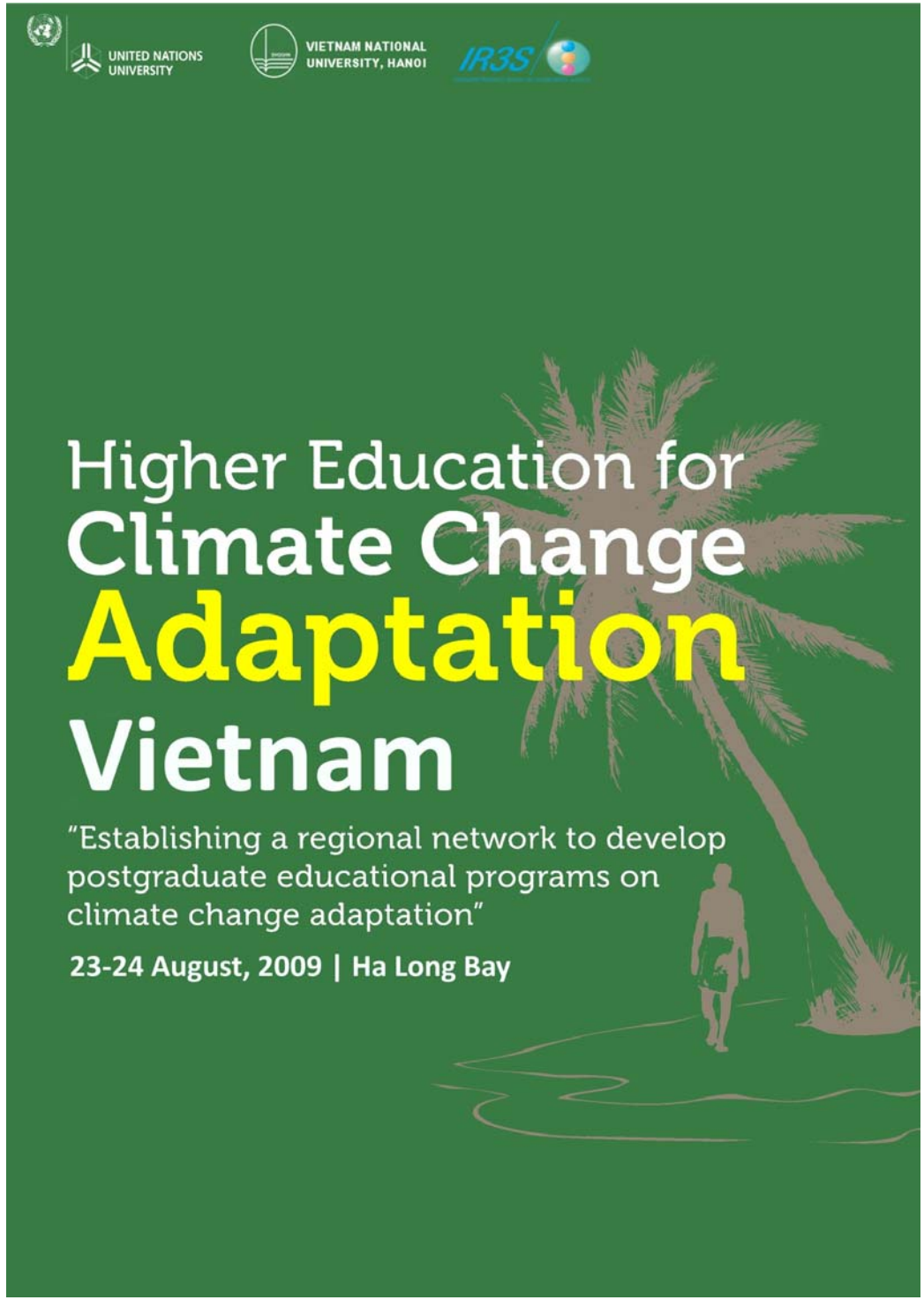
- Currently the founding membership consists of 13 leading universities in AP + 5 from Japan
- Managed by an International Coordinating committee of Universities, and supported by a large body of Advisory group.
- Two working groups
  - Joint research
  - Joint post graduate education programs.



Concluding remarks

- Model based predictions are indispensable to assess climate change impacts on resources, production and extremes.
- It is necessary to bring the tools and methodologies to a larger group of professionals and practitioners.
- Dealing with model prediction uncertainties is the greatest challenge facing designing adaptation strategies and require further research and ground observations.
- New design approaches may be necessary to cope up with uncertainties and higher education sector's leadership is essential to customize global knowledge and improve model predictions to local context.

Thank You for your attention!