Water Resources, Floods and Agro-Environment in Monsoon Asia

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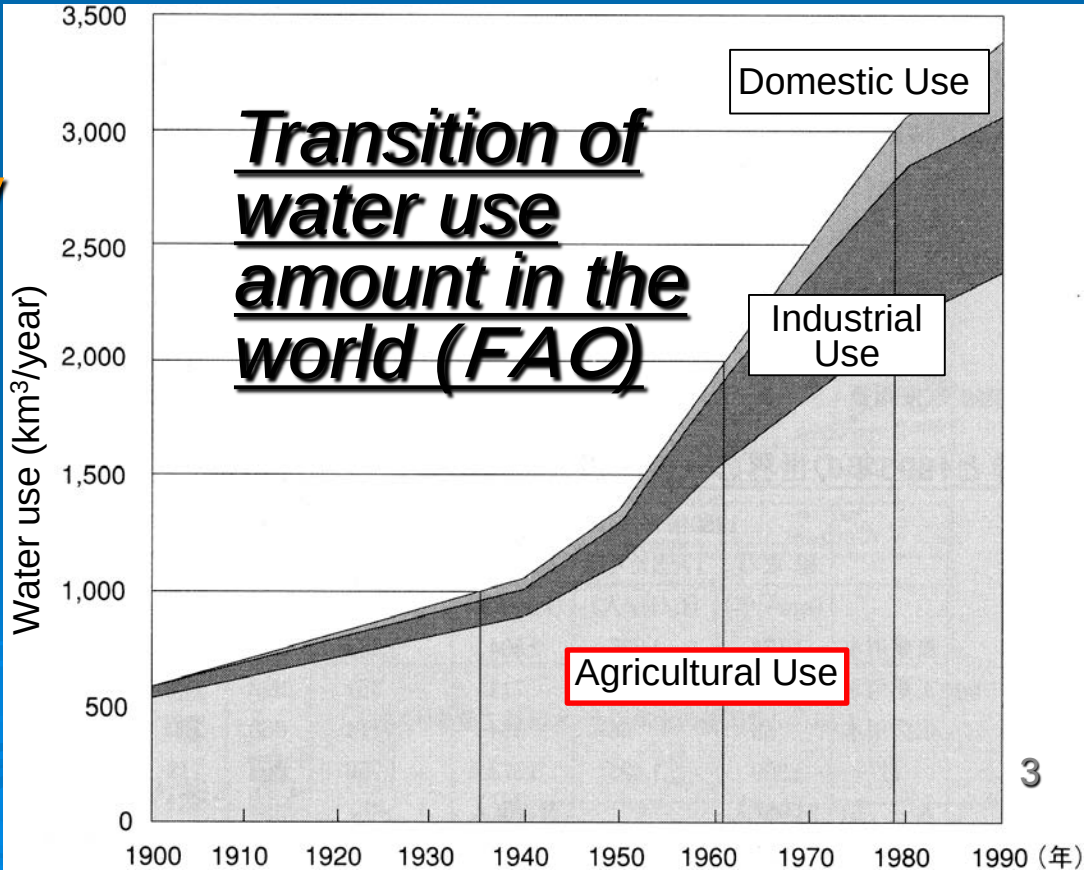
Outline

1) Water resources: "visualization" of water circulation
   - Quantity side in basic process: Agricultural water use plays an important role.
   - Agricultural water circulation = complicated
2) Agro-environmental problems tackled in water resources fields
   - Causes: climate change (extremes), food crisis, energy shortage, catastrophic earthquake
   - Solutions: how to cope with those problems through "Visualization?"
3) Proposals for future subjects in agro-environmental research

Background

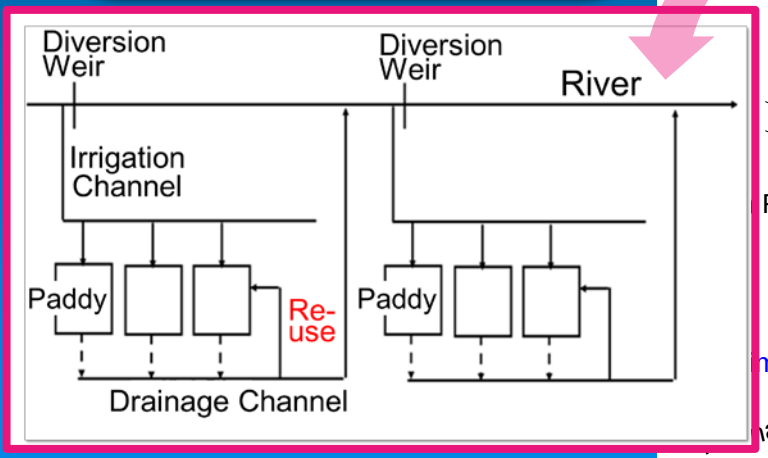
- Rice cultivation in paddies = Not only high productivity, but also sustainable and environmentally friendly economic activity
  (Ex: 7,000-year-old rice cultivation in China)
- Share of Agricultural water use → 70 %
- Coexistence of Variety
  - i) Distinct wet and dry seasons → [Large vulnerability, Extremes (droughts and floods)]
  - ii) Various types of paddy irrigation
- Agriculture→Human activities→Anthropo-genic change

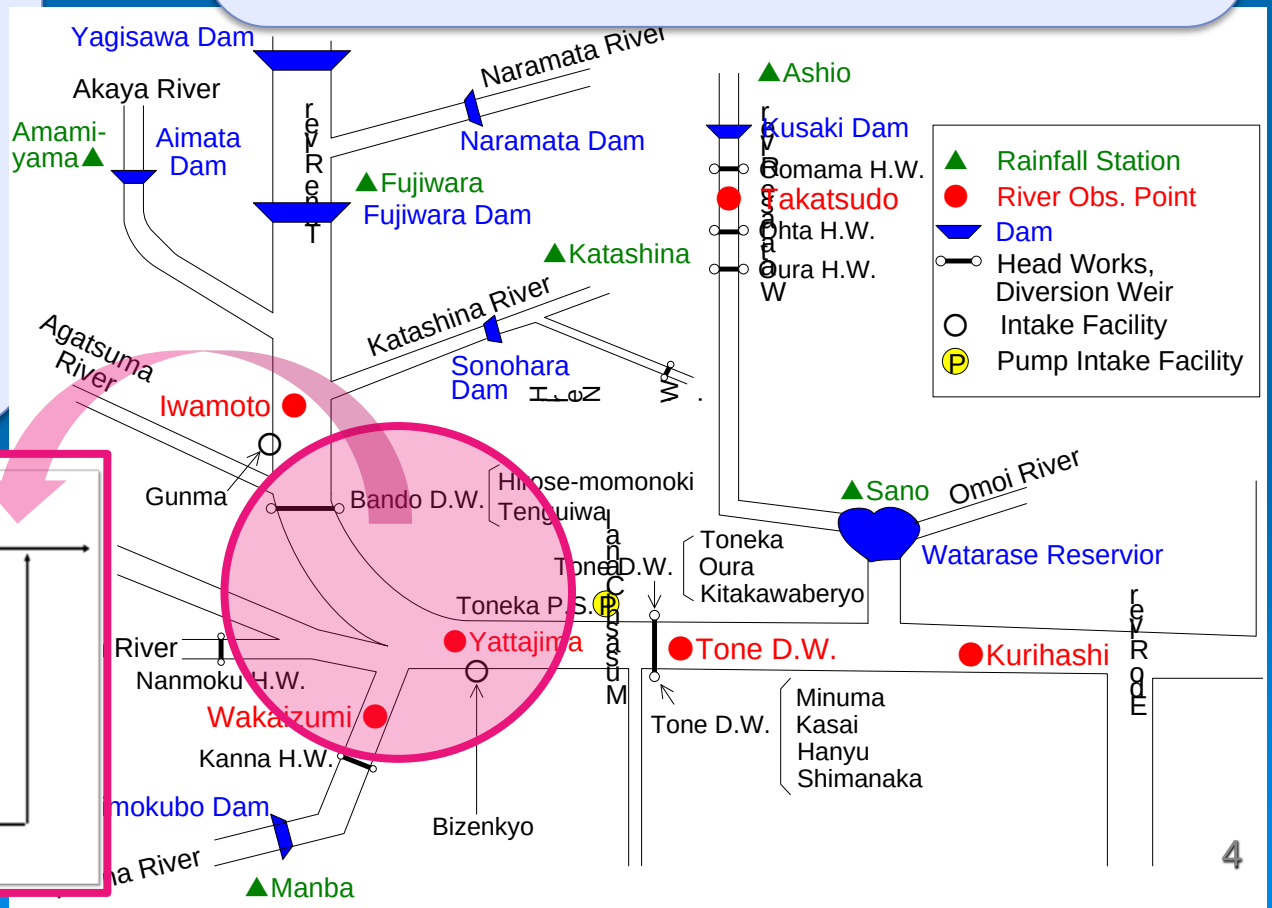


Complicated agricultural water use (Tone River Basin as an example)

- Diversity of irrigation (Various types)
- Dissimilarity between dry areas (field crop) and humid (paddy rice) areas
- Repeated use of irrigated water

- Difficult to grasp water resources under complicated water use → [Visualization of water circulation]

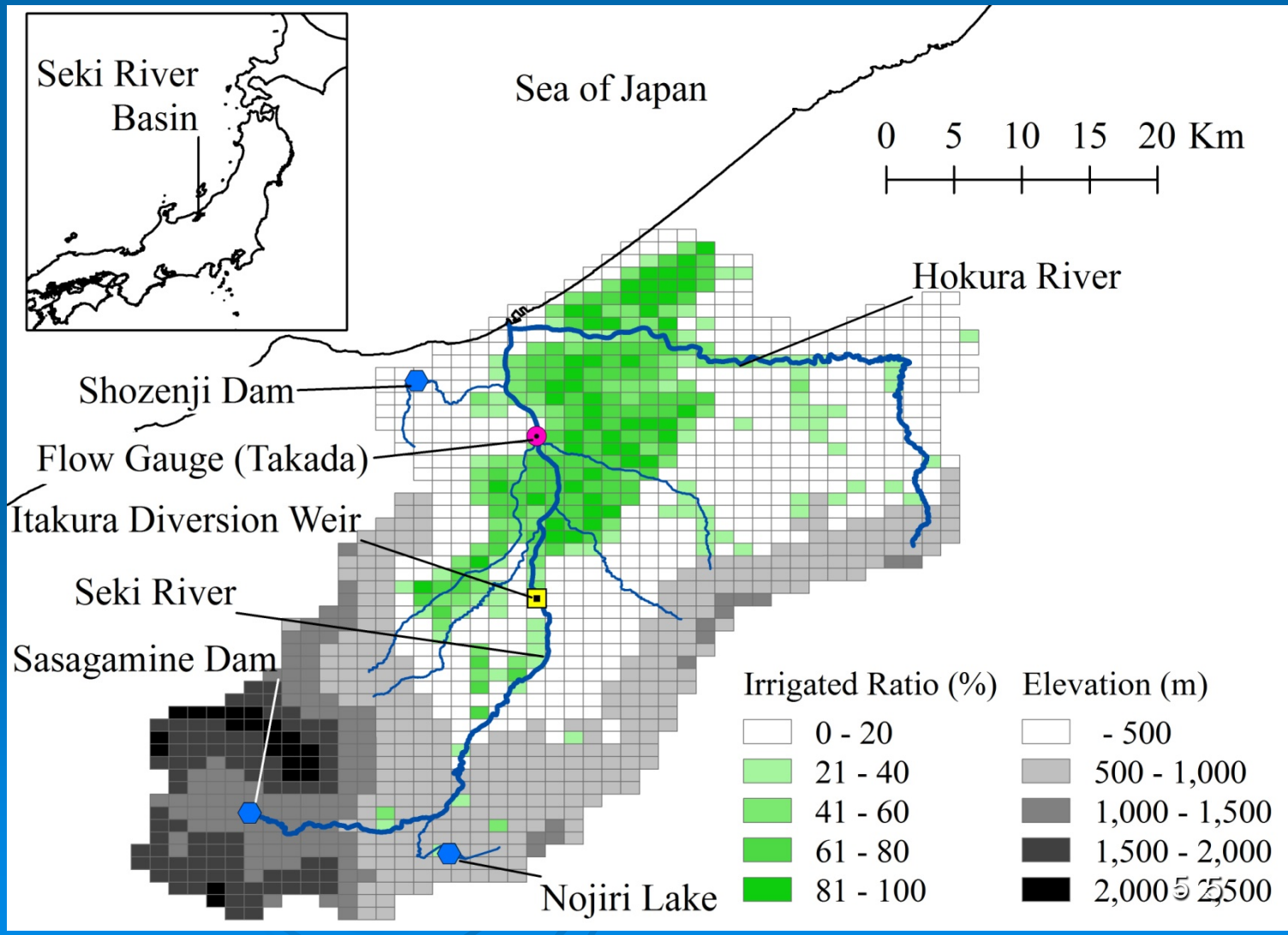




A Typical Irrigation Dominant Basin

Seki-River Basin

- Area : 1,140km^2, Length : 64km



A Typical Irrigation Dominant Basin

Part 1 Method and Approach for the Visualization

(A) Hydrological Phenomena,

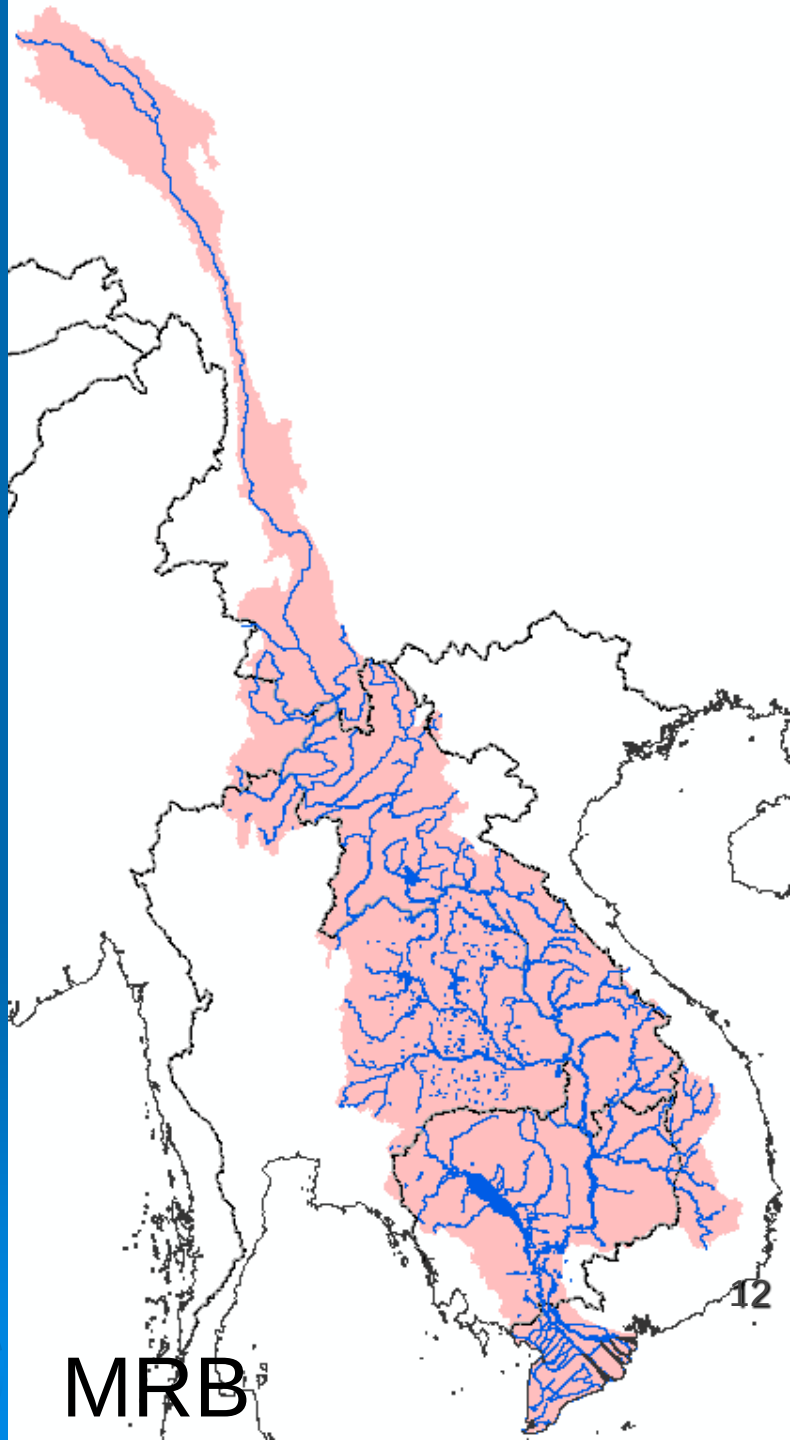
(B) Anthropogenic (Human/ Artificial/ Agricultural) Activities

Mechanism of Agricultural Water Use (Observ. & Model →Which Target Basin?)

Paddy agriculture (global dissemination)
Monsoon Asia (East, South-East, South), Australia, Europe [Italy, Spain, France etc.], USA [California St. etc.]

Mekong River B.: A huge river basin in Monsoon Asia

- China, Myanmar, Laos, Thailand, Cambodia, and Vietnam (6 countries)
- Area size (800,000 km^2)
- River length: 4,880km (the longest in S.–E. Asia)
- Flooding in lower reach
- Min/Max of dis.): 40～50 [1,800m^3s^{-1} / 43,000m^3s^{-1}]
- Paddies dominant (70%)



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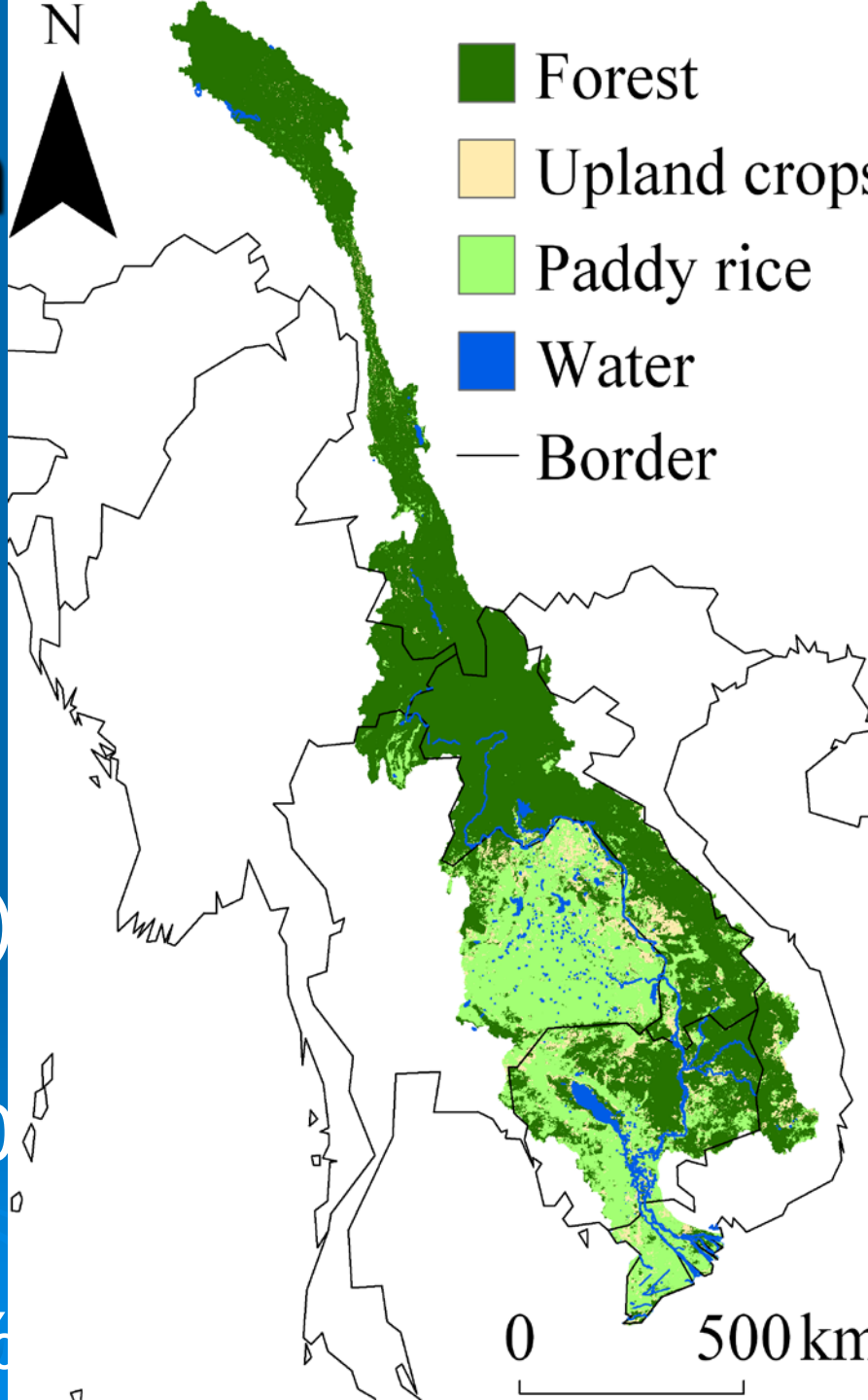

Extremes in the Mekong

Record Flood in Year 2000 in the Mekong River Basin (An event of once in 30-60 years)

Components in Runoff and Water Allocation & Management System

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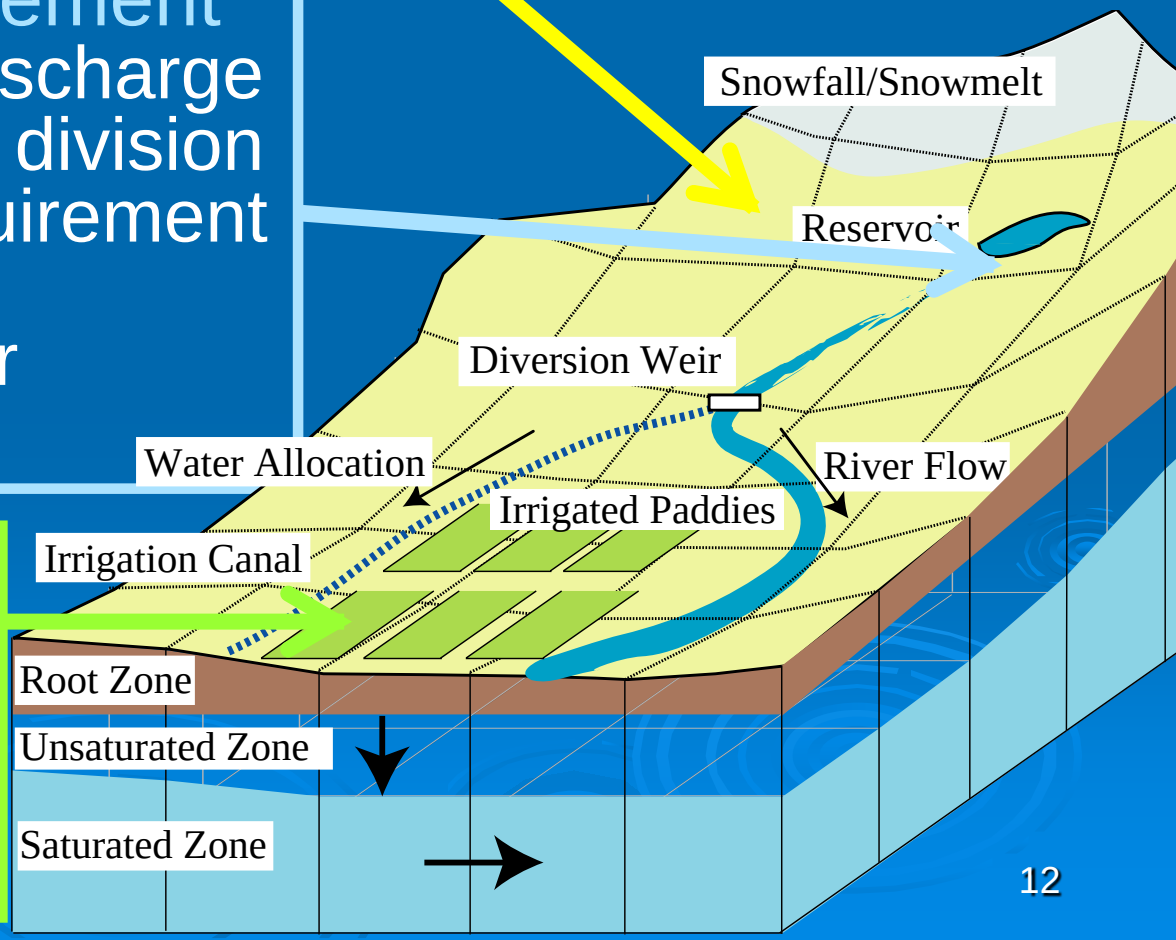
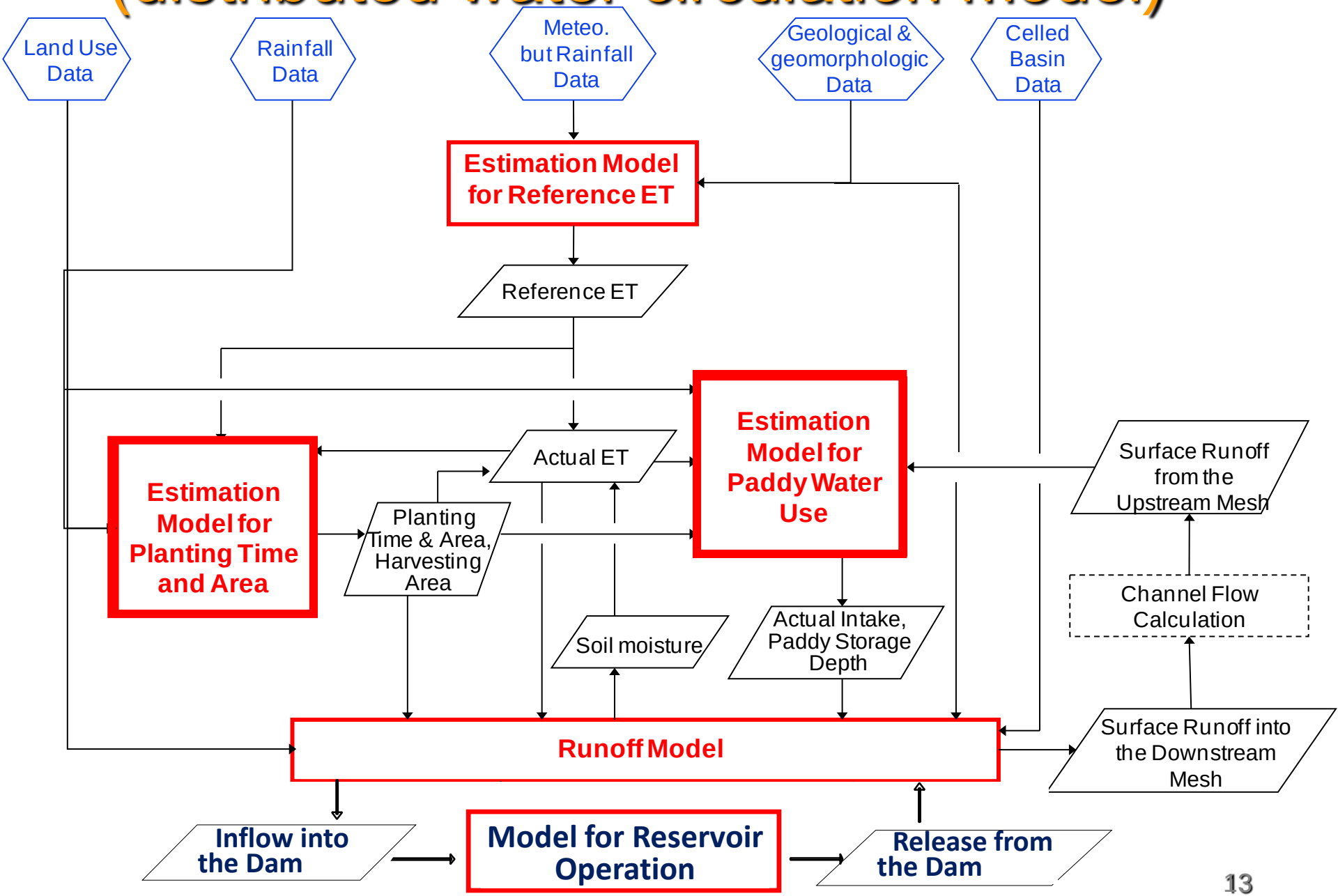
i) Basin-wide Runoff
- DWCM-AgWU Model

ii) Reservoir Management
- To compare river discharge (available water) at division weir and water requirement in irrigated paddies
- To release water for irrigation

iii)Water Delivery in Irrigated Paddies
- To decide intake, water allocation, infiltration, drainage



Calculation algorism of DWCM-AgWU (distributed water circulation model)



Variability of agricultural water use modelled in the basin

[Rain-fed paddy: 3 types]

- Using only rainfall
- Supplementary water use (small ponds)
- Using Flood water

14

Variability of agricultural water use modelled in the basin

[Rain-fed paddy: 3 types]

Using only rainfall

Supplementary water use (small ponds)

Using Flood water

15

Variability of agricultural water use modelled in the basin

[Rain-fed paddy: 3 types]

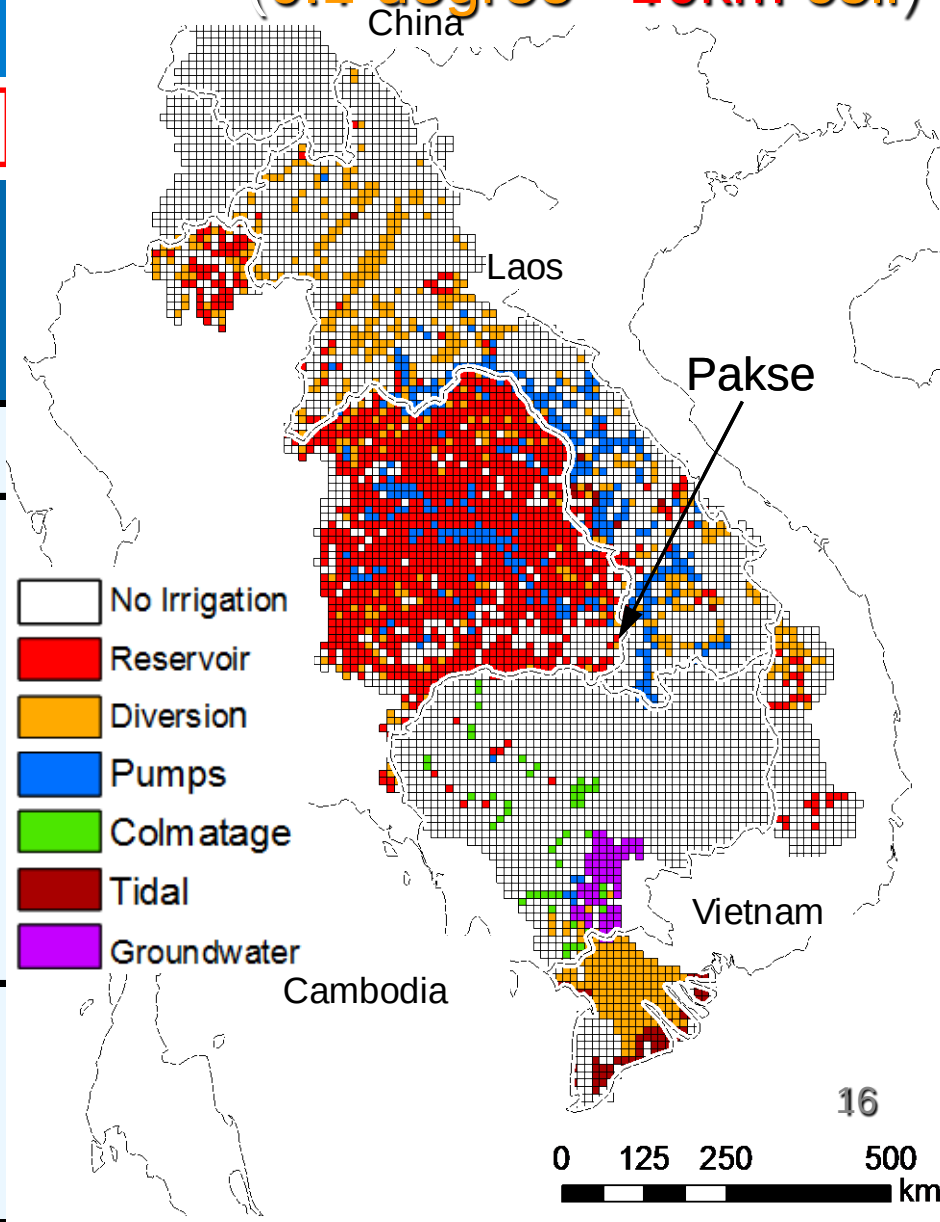
Using only rainfall

Supplementary water use (small ponds)

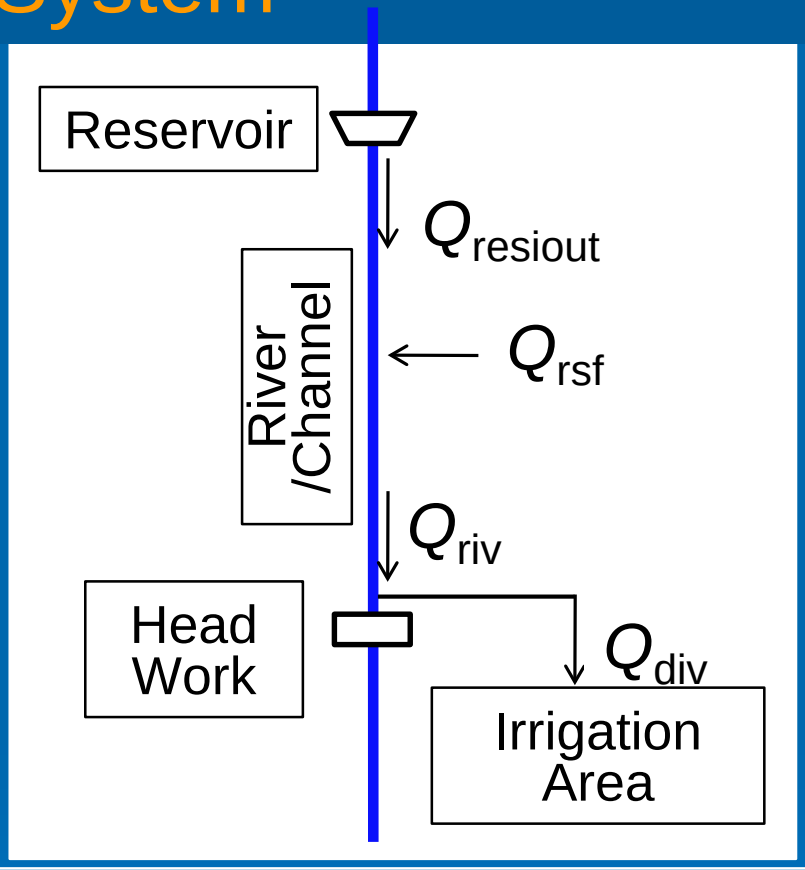
Type	Classification
Irrigated	Gravity irrigation (Weir) Pump irrigation Reservoir supply Colmatage system Tidal irrigation (Sluice) Tube-well (Ground water)
Rainfed	Rainfall Supplemental water use Flooding water

[Irrigated paddy: 6 types]

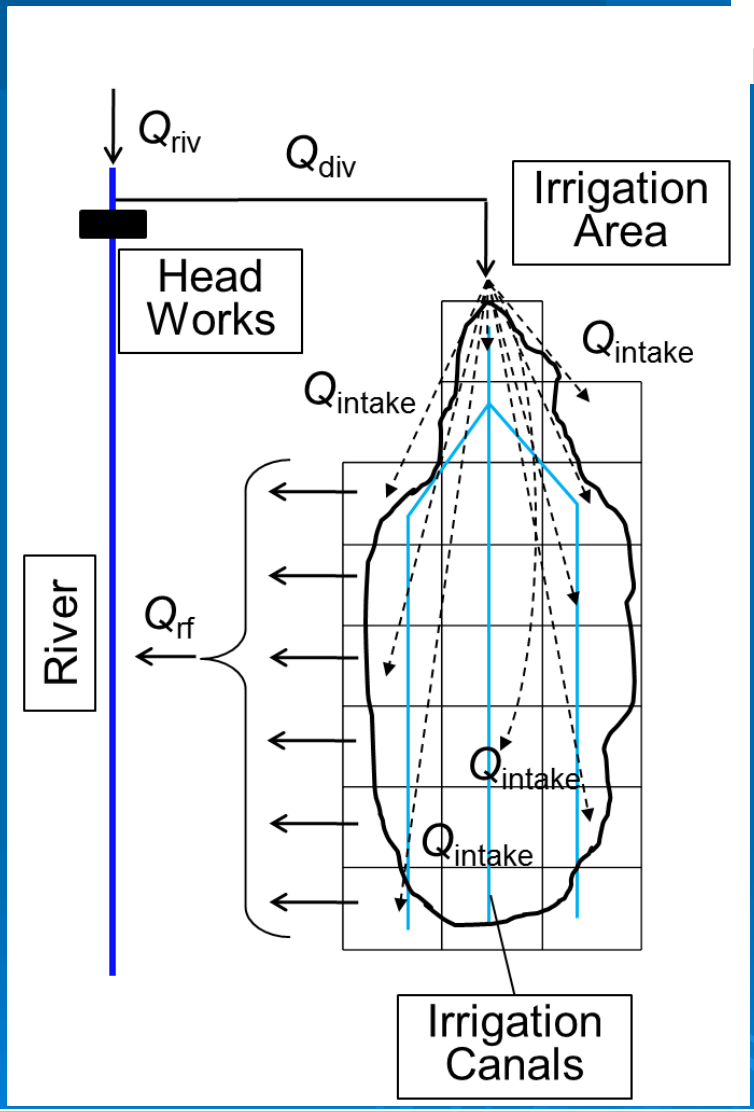
(0.1 degree =10km cell)



Modeling of Release and Water Delivery System



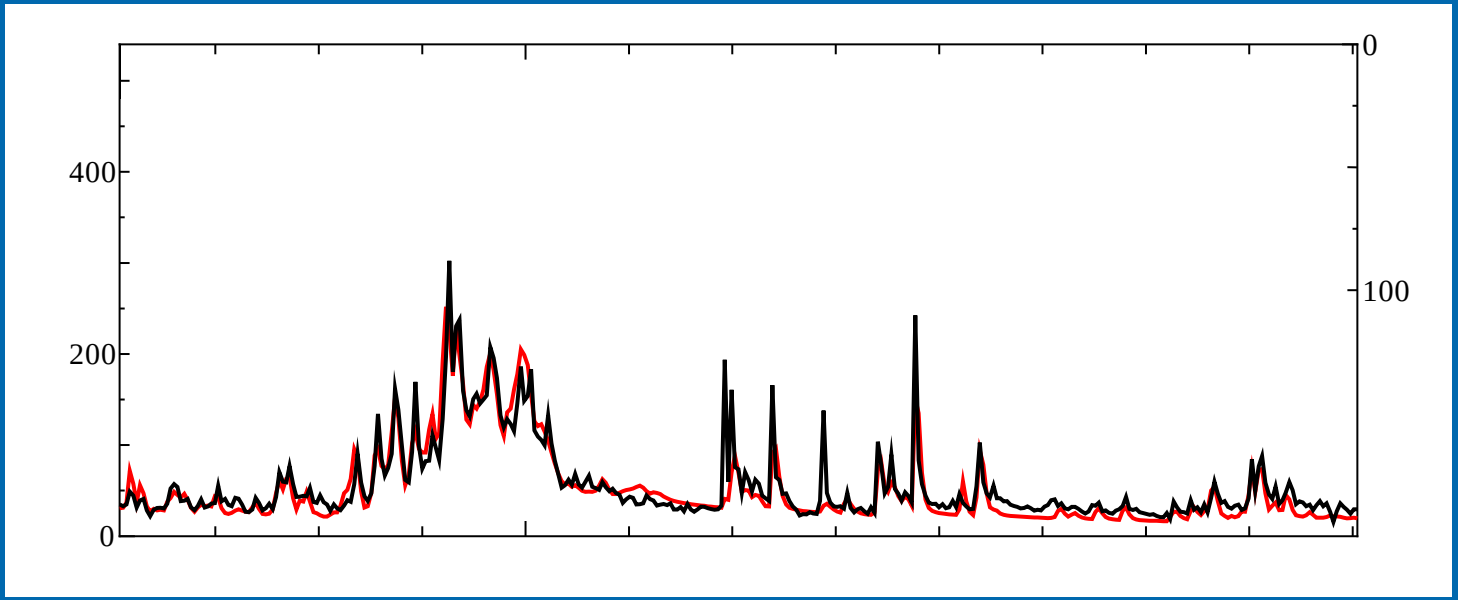
$Q_{resiout}$: Release for Irrigation
Q_{rsf} : Runoff from Remaining Area
Q_{riv} : Discharge at the River ($Q_{resiout} + Q_{rsf}$)
Q_{div} : Intake at Head Work



Q_{div} :Intake at Head Work, Q_{intake} : Delivery Water, Q_{rf} :Return Flow, Q_{riv} :River Discharge

Verification of DWCM-AgWU Model

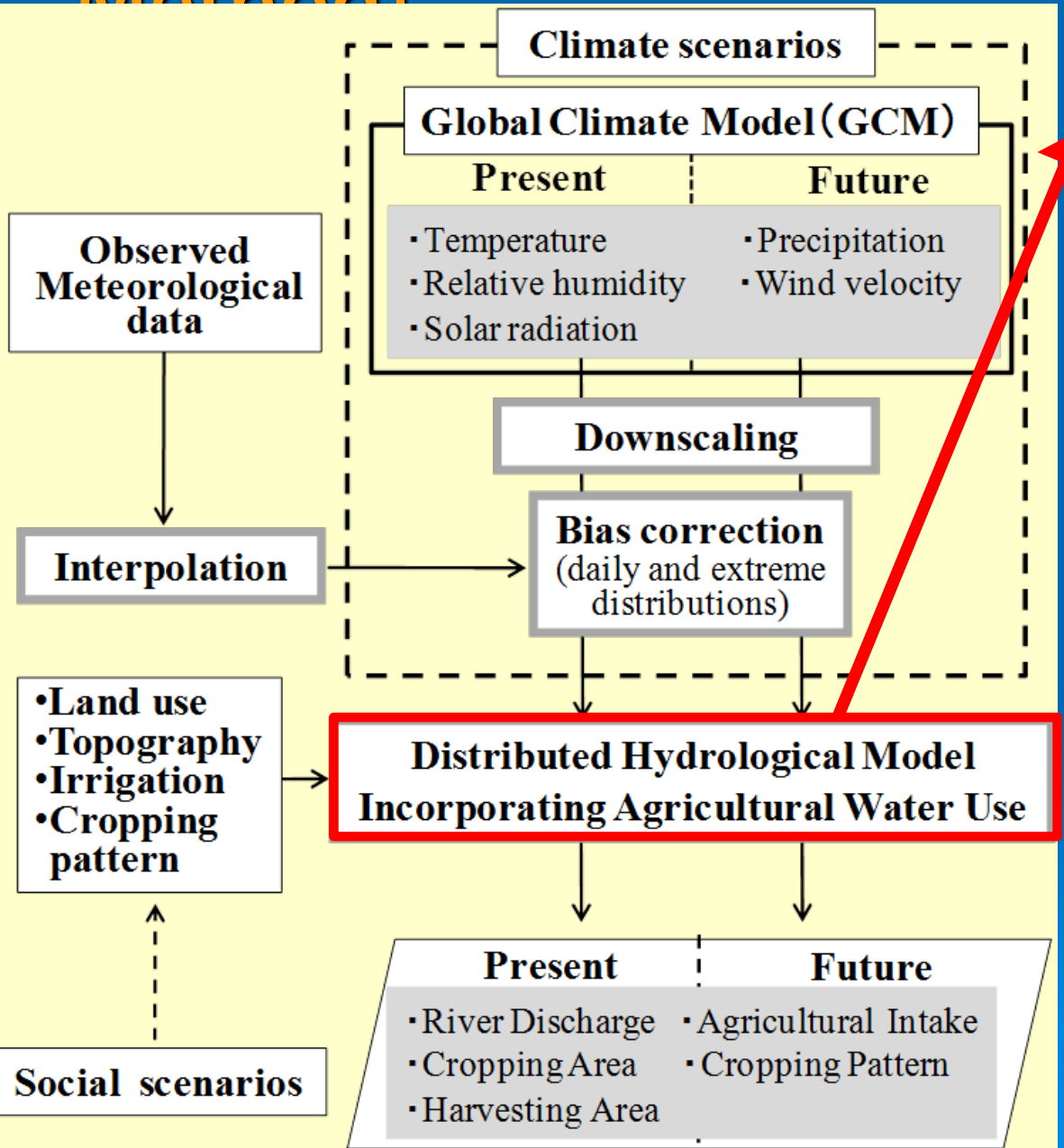
(i)Natur. runoff, ii)Dam manag., iii)Water allocat.)



Part 2 Agro-Environmental Problems Tackled in Water Resources Fields

→ "Visualization" did not abruptly occur, but it has been involved in social conditions (problems) occasionally (5 applications).

[Application 1]Climate Change Issue (Core tech.: Impact Assessment Method)



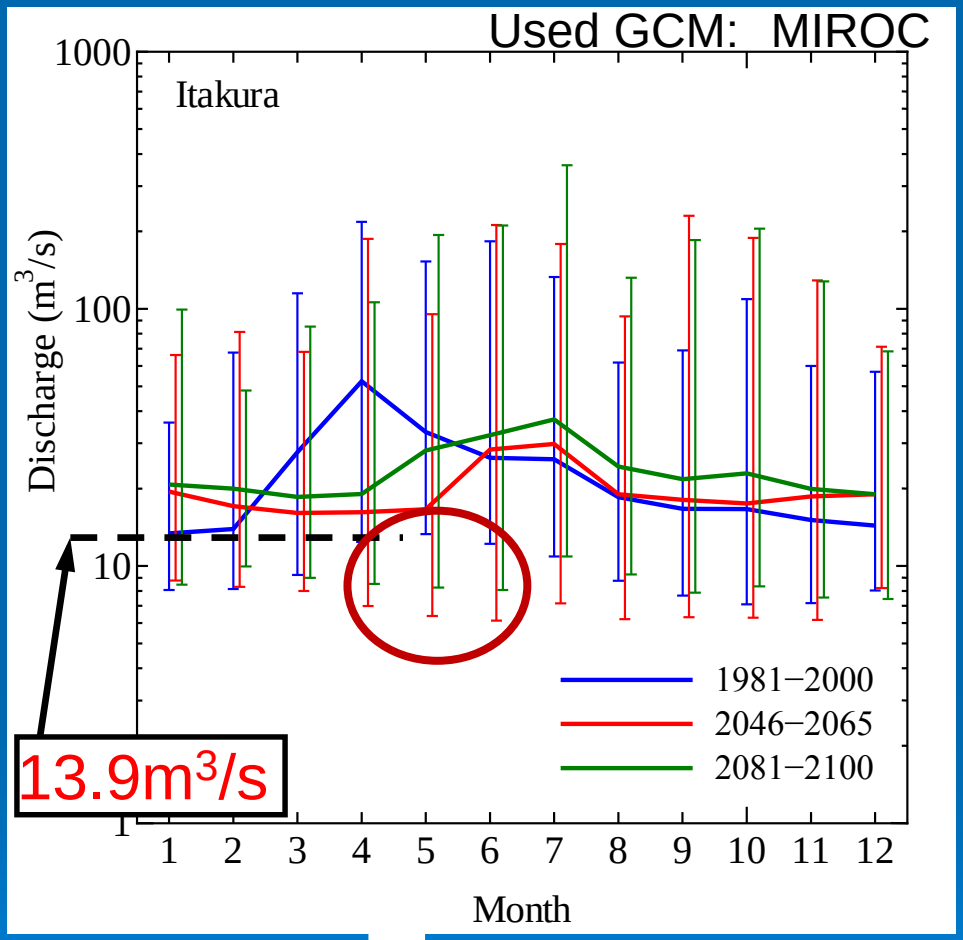
Basic technology

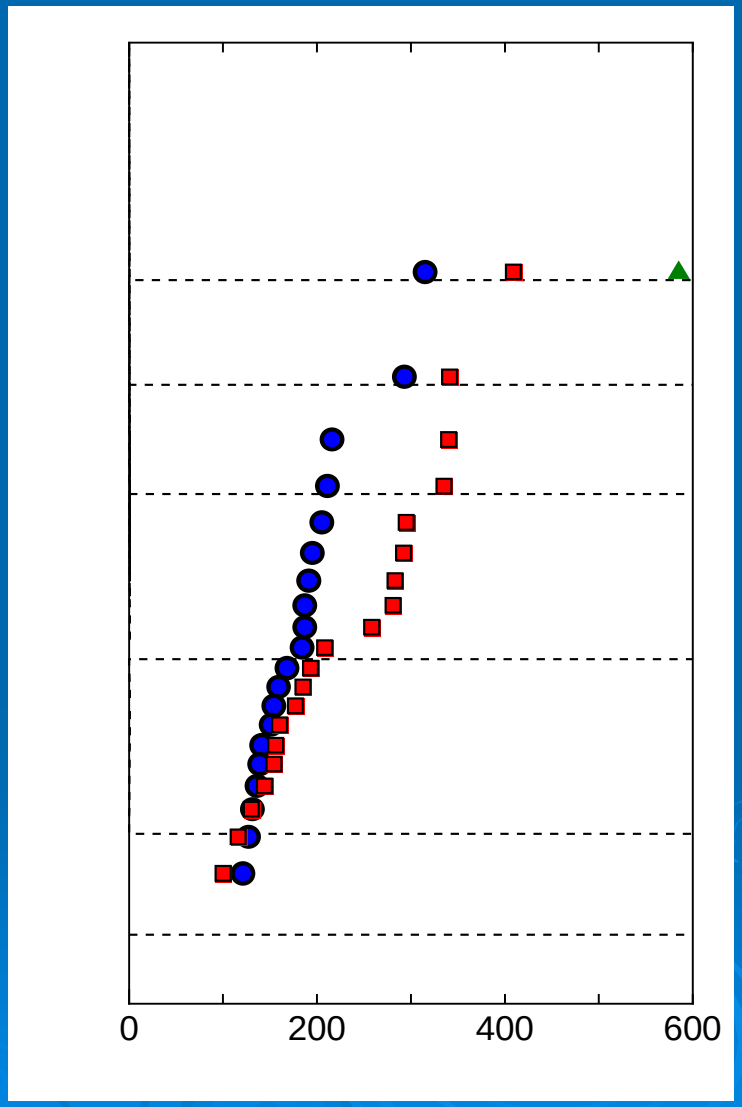
- DWCM-AgWU Model

Characteristics

- Able to carry out quantitative estimation at any time and space
- Able to estimate agricultural intake, planting/harvesting time/area, under various social scenario

Assessment on Extremes (Irrigation, Flood: “Itakura” Div. Weir Pt.)



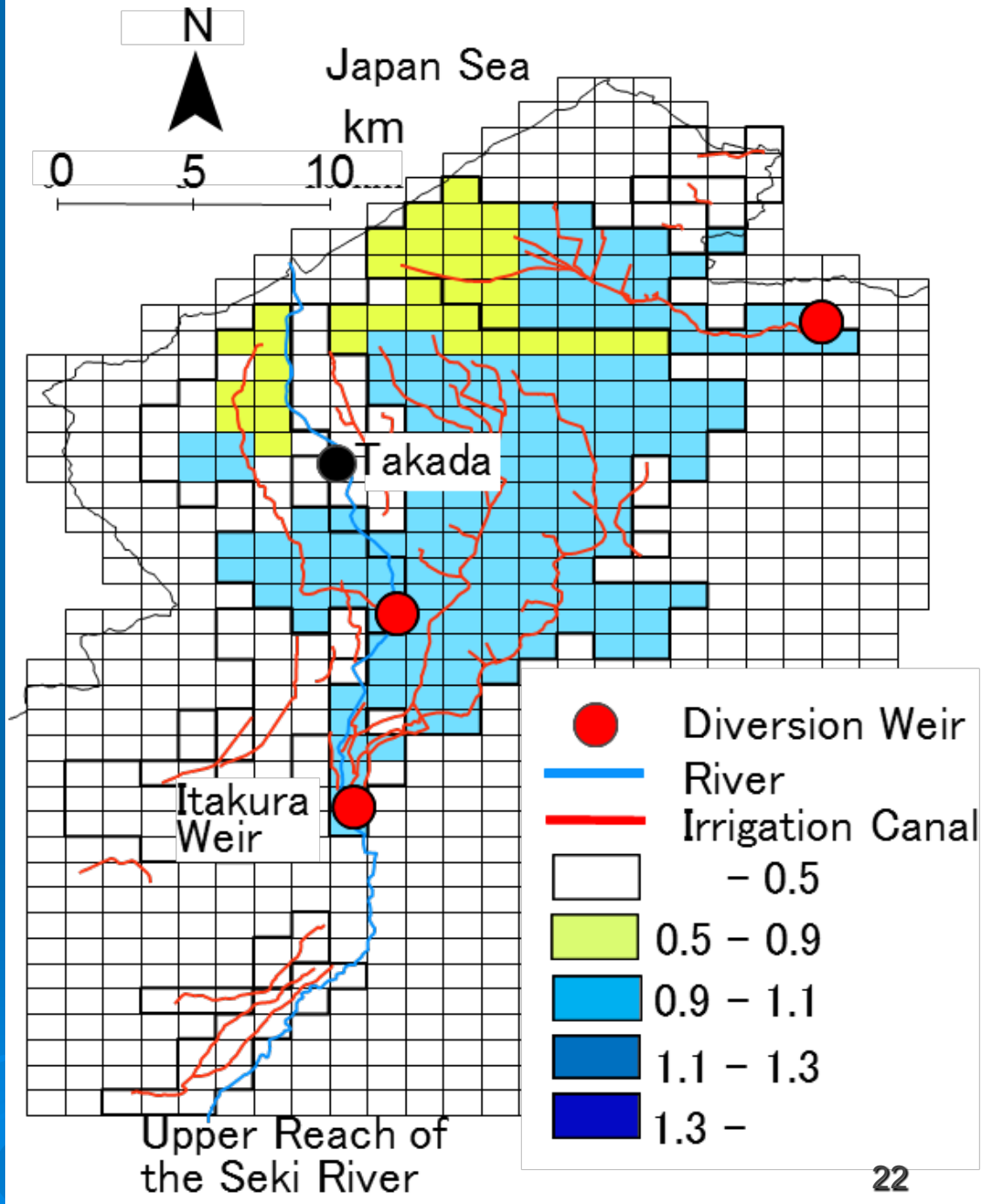


Apprehension not to intake enough water to “water right amount” in the future

Future change of irrigation water

Ratio of irrigation water in the future compared to the present

（The rate of the end of the 21 C. [2081-2100] to the present [1981-2000], (ex.: prediction during puddling periods)



[Application 2] Overseas Assistance Problems in Agro-Environments

- Basins for the application trials

  The whole Mekong River Basin

  Pursat River Basin (Cambodia)

  (Irrigation development in areas with scarce data)

  Nam Ngum River Basin (Lao PDR)

  (New water res. development for hydro-power)

  Xe Bang Fai River Basin (Lao PDR)

  (Annual flooding in paddies of the lower reaches)

  Mun-Chi River Basin (N.E. Thailand)

  (Irrigation by large- & medium-scale dams)

  Chao Phraya R.B.(Thai) (2011 flood & agri. water use

- All Monsoon Asia → All over the world ?

Disordered Development due to the Lack of Fundamental Data

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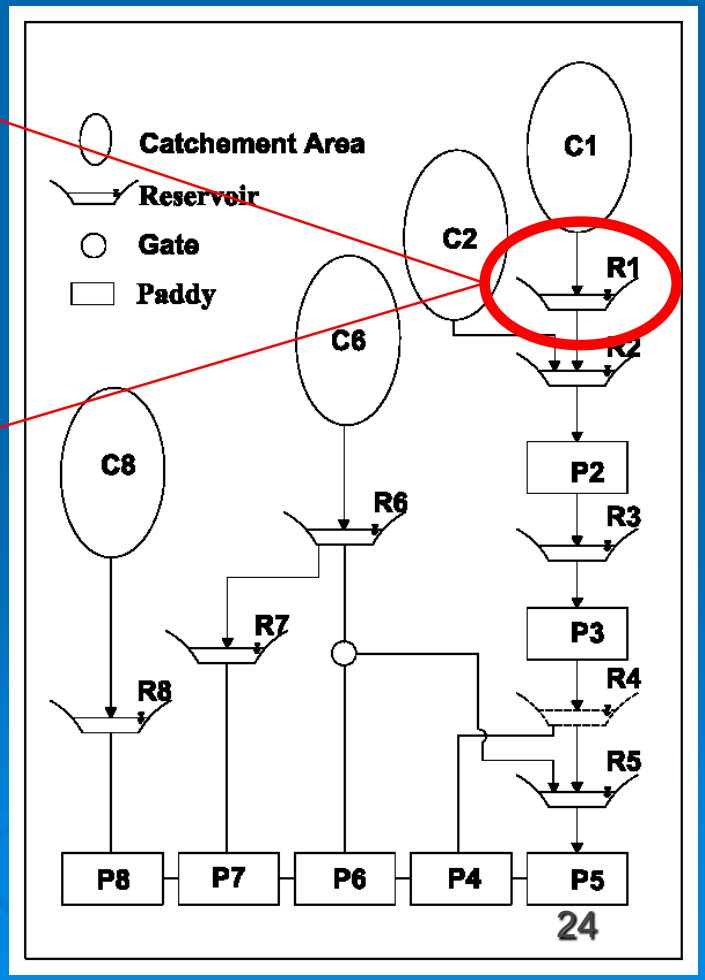
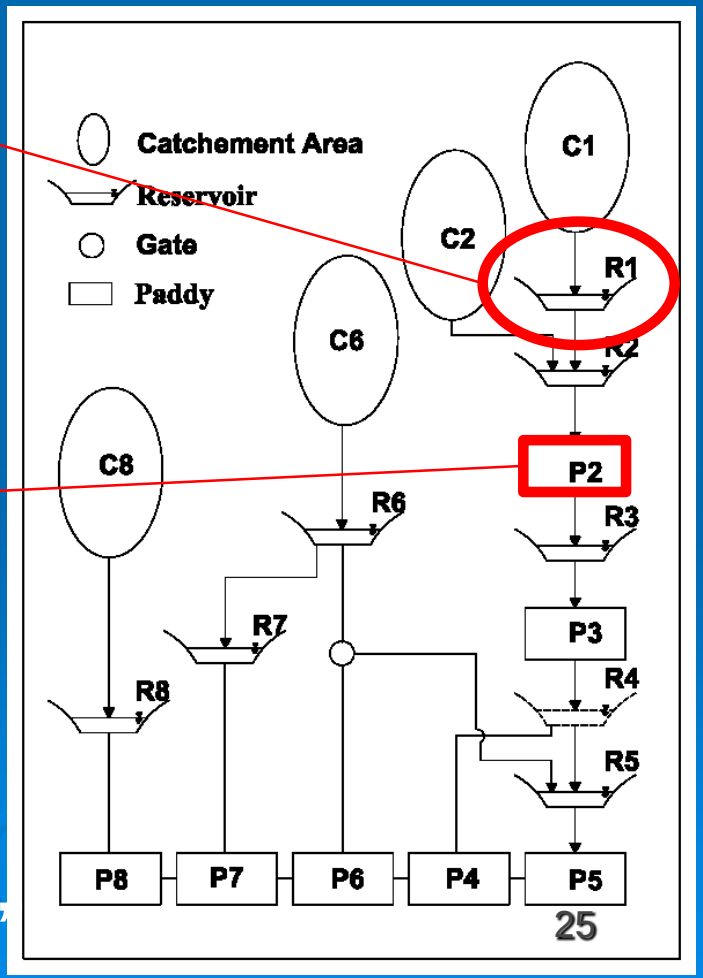
i) Disordered plan



Disordered Development due to the Lack of Fundamental Data

→ ii) Break of embankments→ iii) Severe damage in the downstream



- Necessity of seamless simulat. for low-flows & floods
- Proposal of "Basin-wide Irrigat."

Extraction of Experiments and Assessment Method

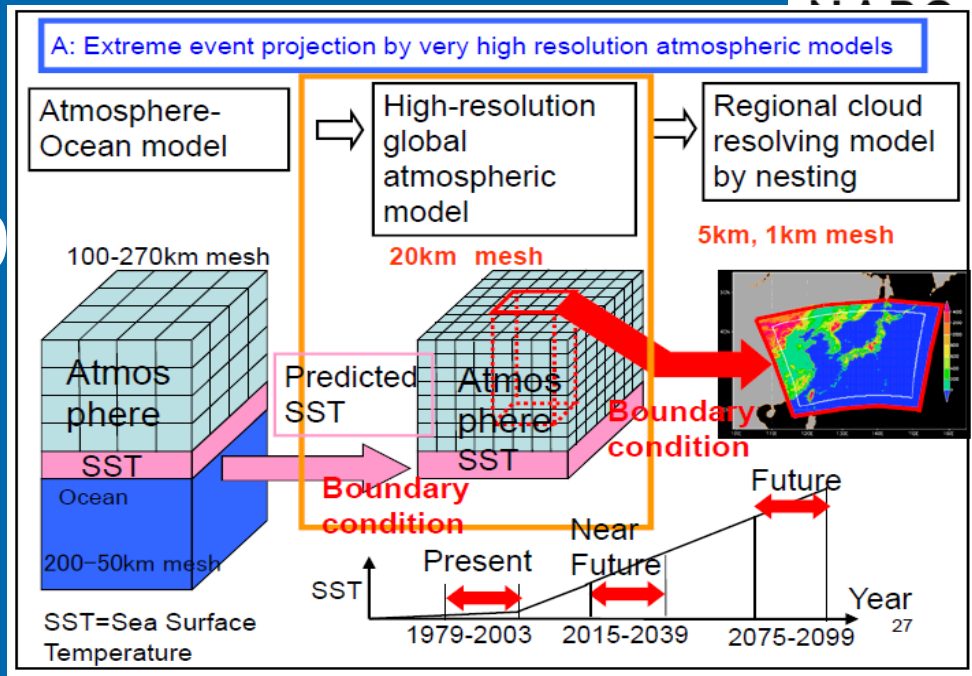
Present: 1979～2003
Near Future: 2015～2039
End of 21st C.: 2075～2099

Meteo. data

- ✓Daily Precipitation
- ✓Daily Max, Min, Ave. Temp.
- ✓Humidity, Wind Speed (6-hour interval)
- ✓Pressure to mean sea level (6-hour interval)

Extract the Mekong R. B. Area from results of MRI-AGCM20

- 0.1° Interpolation, Bias Correction
- Simulation by the Assessment Method



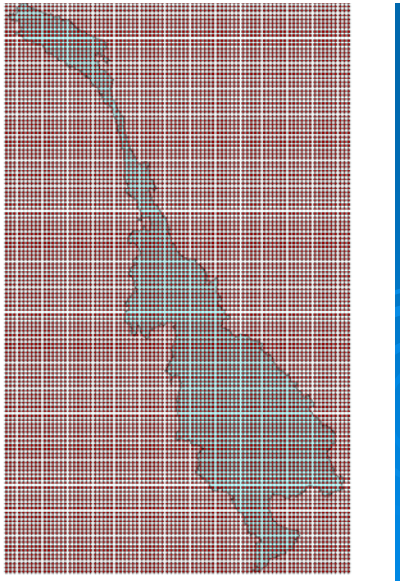
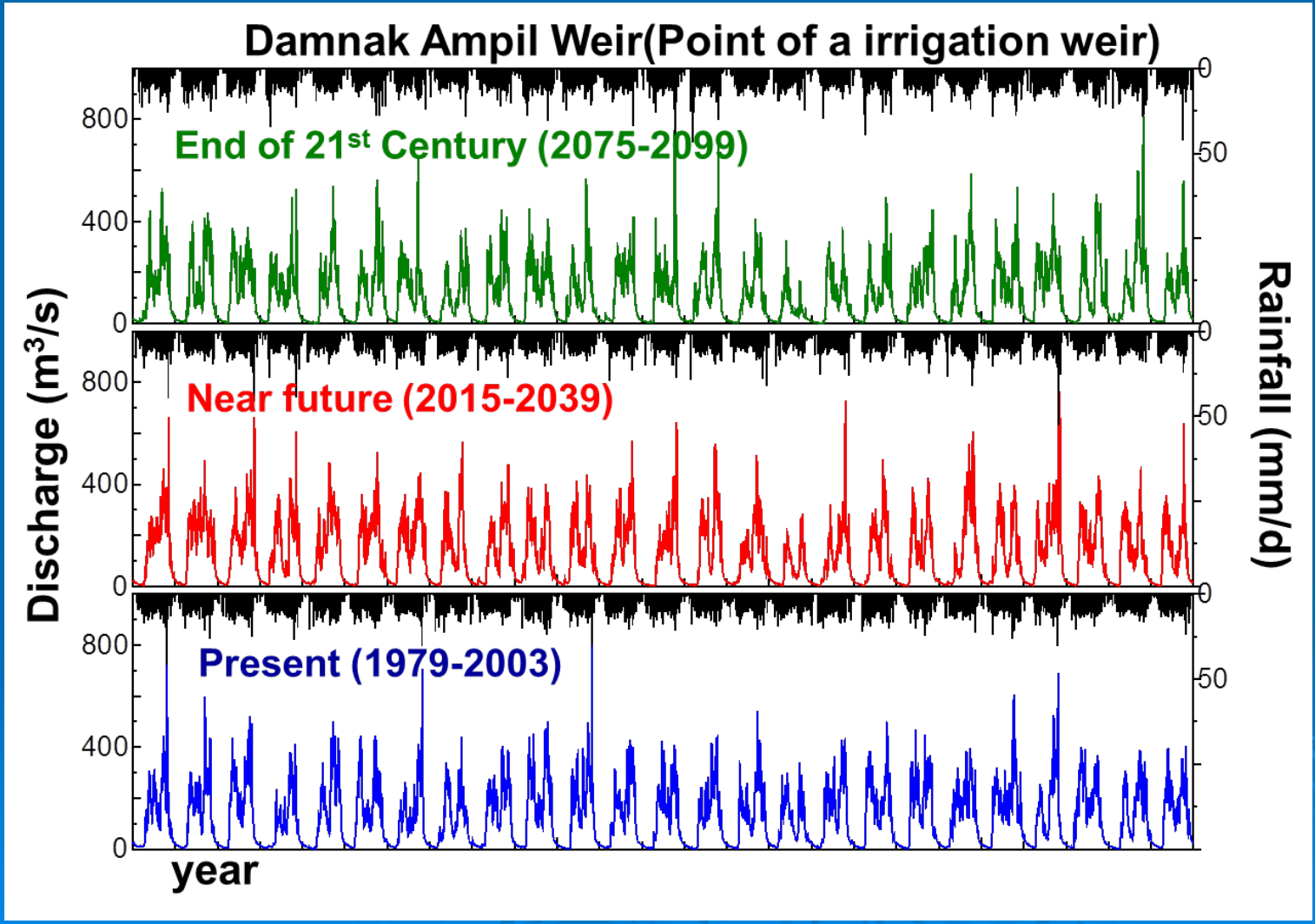


Fig.:Calculation domain by GCM20

Brown dots: GCM20 Calc. nodes

A New Approach for Generation of Long-term Continuous Data

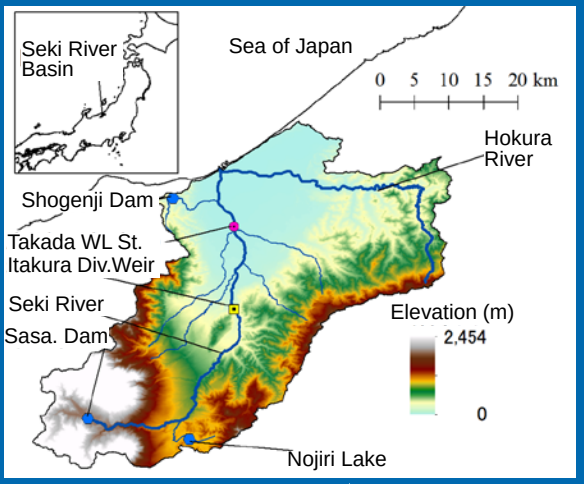
DWCM-AgWU→Generation of Quasi-Obs. Data



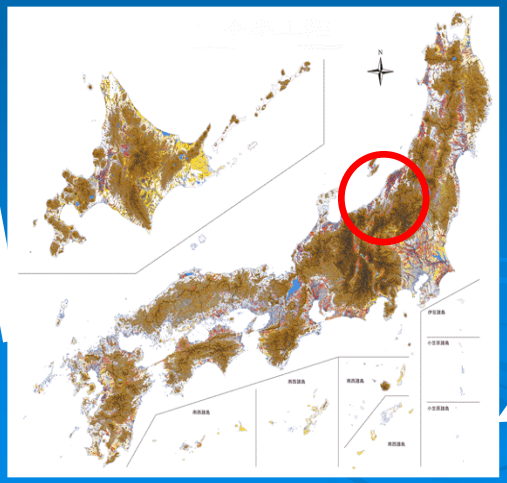
(ex.) Daily simulation for 25 years in the Pursat River B.

[Application 3] Extension to Food Problems, Socio-Economical Assessm.

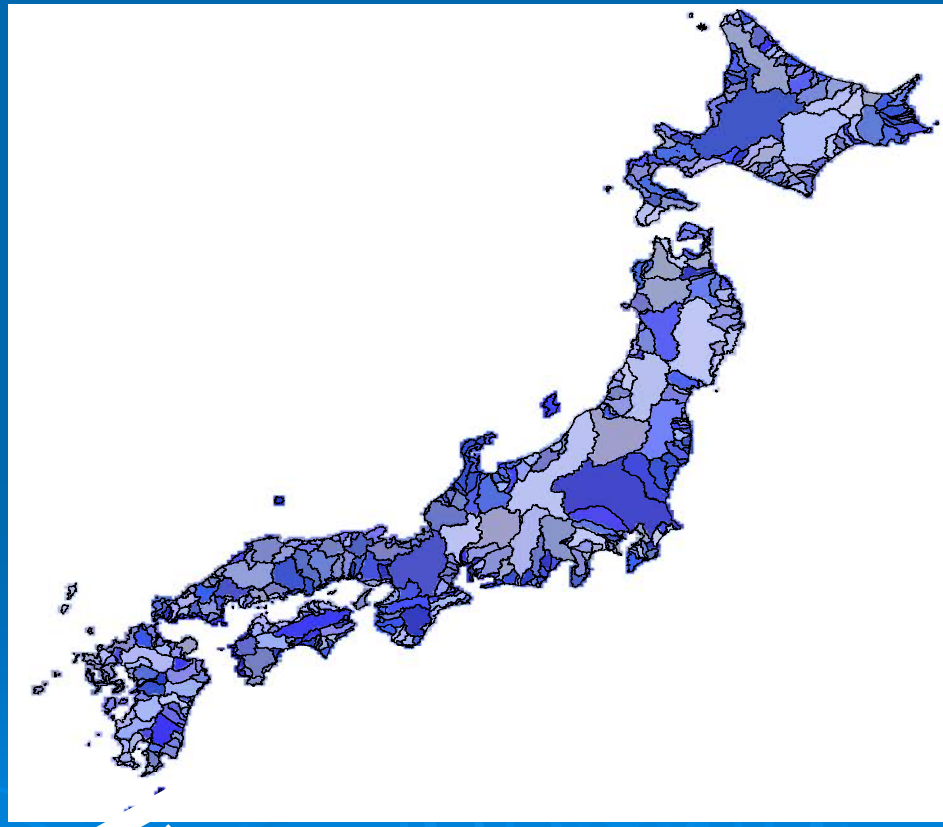
- To all the basins of Japan, impact and scio-economic assessments on foods, agricultural water, irrigation facilities



(c) "Seki" River Basin

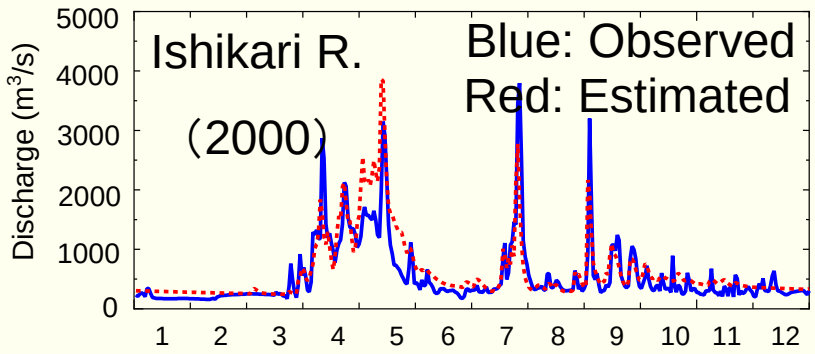


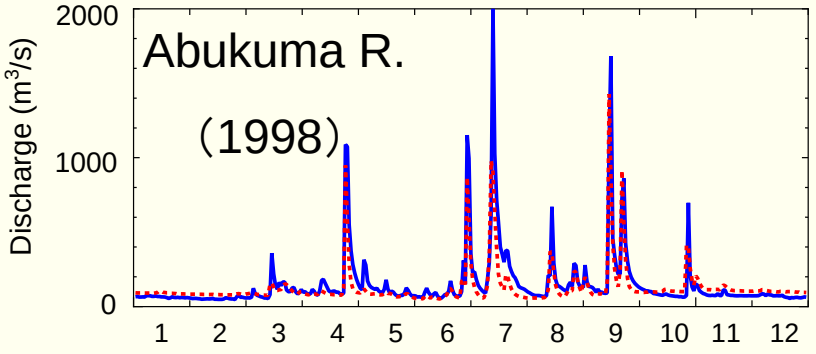
(b) All Japan

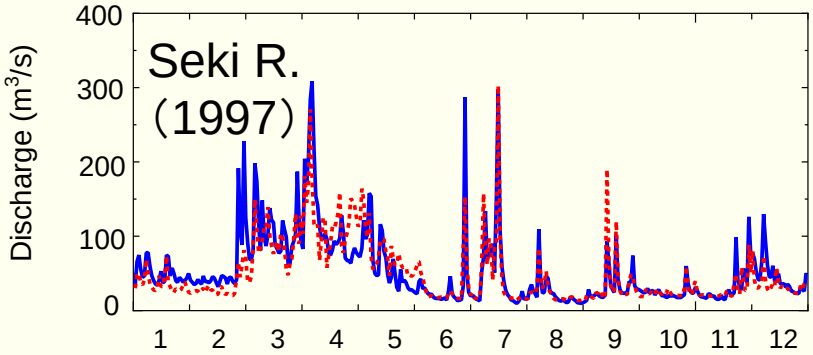


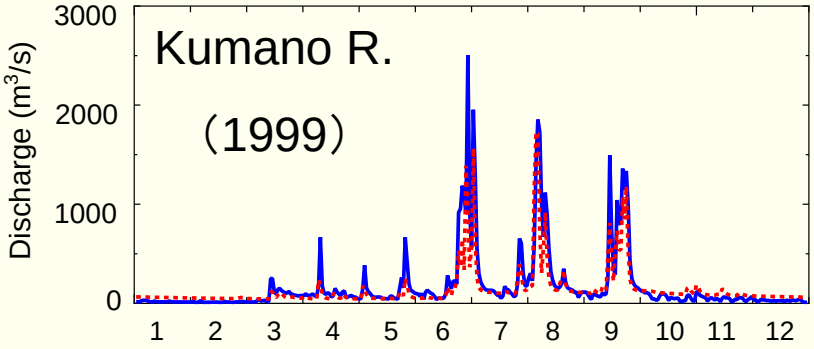
(a)1～5km Cell accuracy (336 basins in the whole Japan)

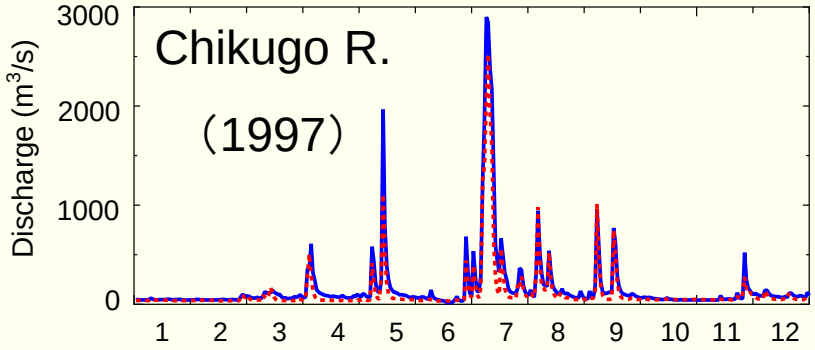
Verification of estimated values for all over Japan

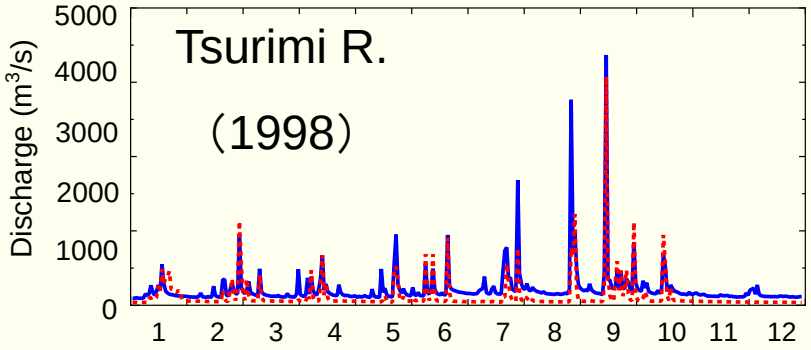








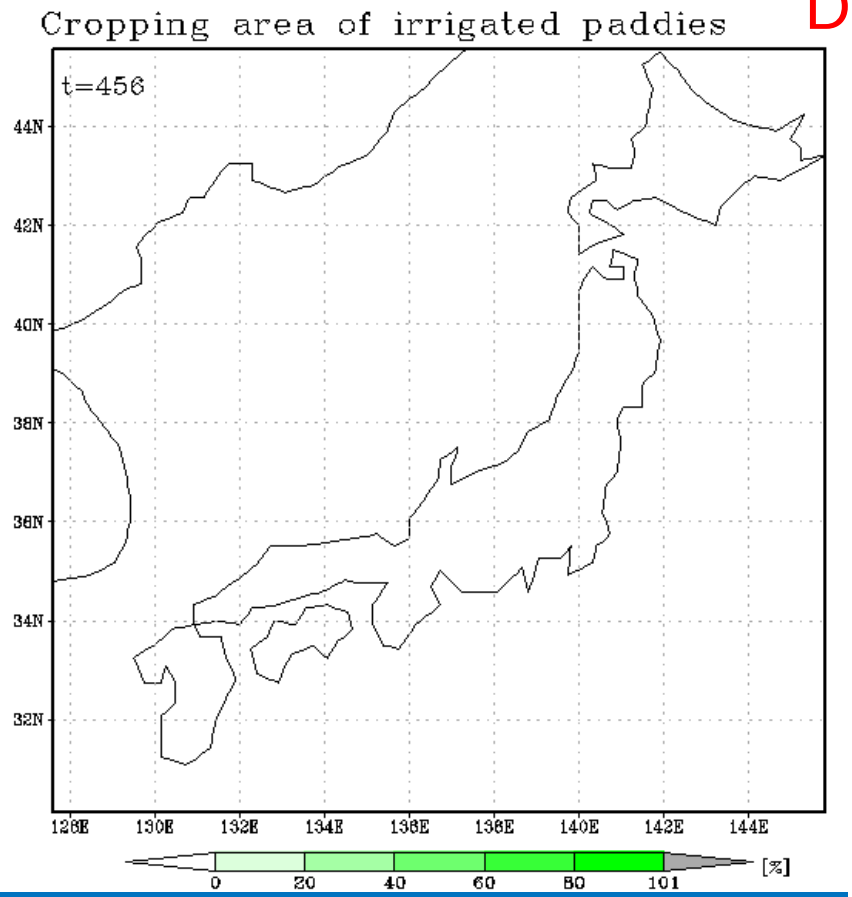


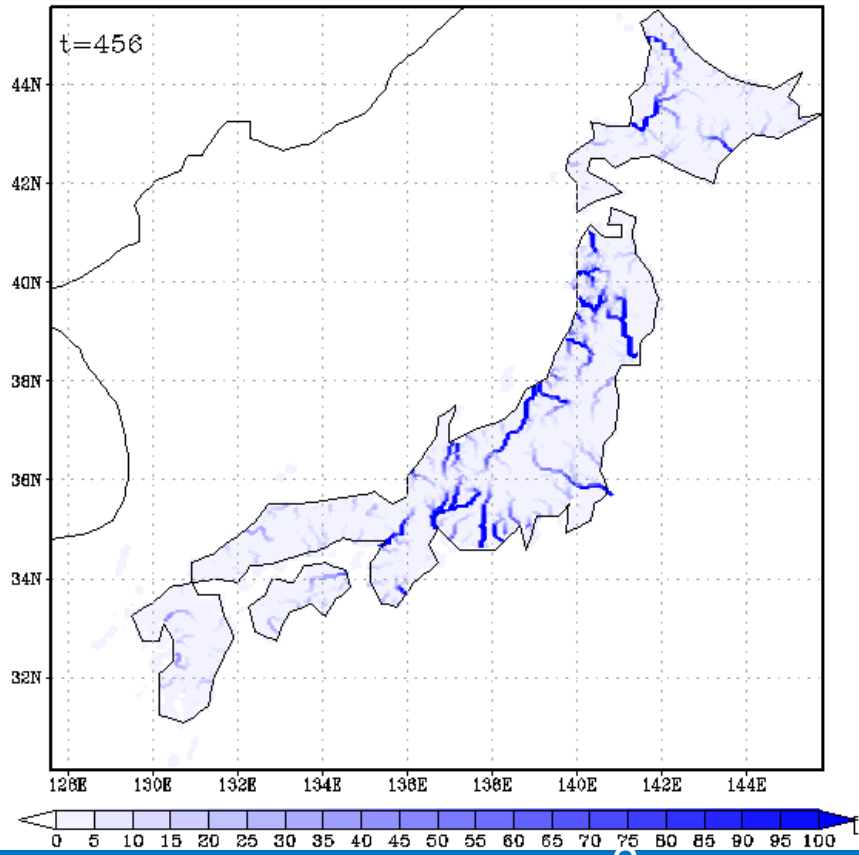


- Satisfactory results of the estimations
- To be improved for Industrial and Domestic sewage in urban-dominant basins

Application of the Regional Water Allocation and Management Model

Daily Estimation by 5km Cells





Planting of paddies (Area: %)

Start/Stop: determined by cultivation day, irrigation amount, rainfall, soil moisture condition etc.

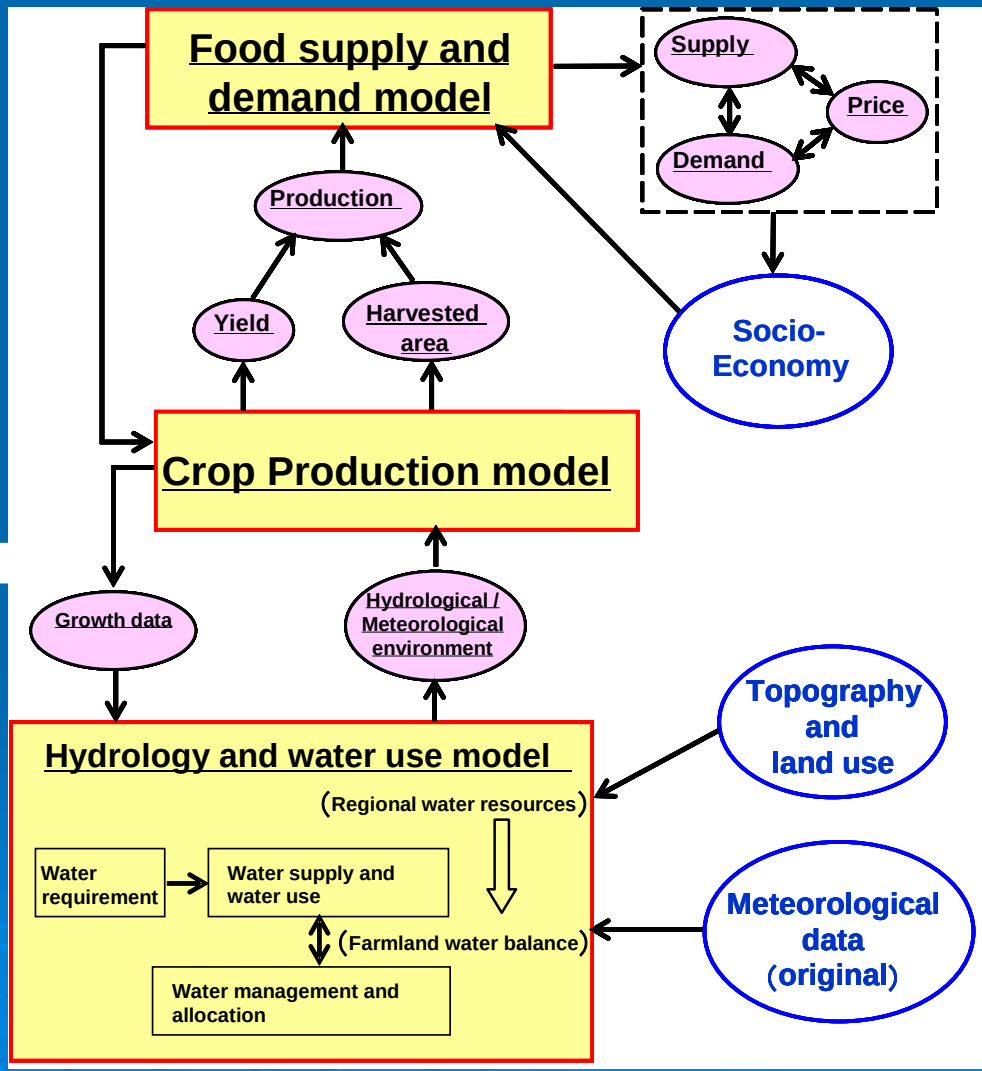
River flows (m^3/s)

Discharges (flow in a cell center plus upstream inputs) estimated at arbitrary points and times

Food Security (Develop. of AFFRC Water-Food Model)

- Convergence with Various Sectors (Agronomy, Socio-economics)

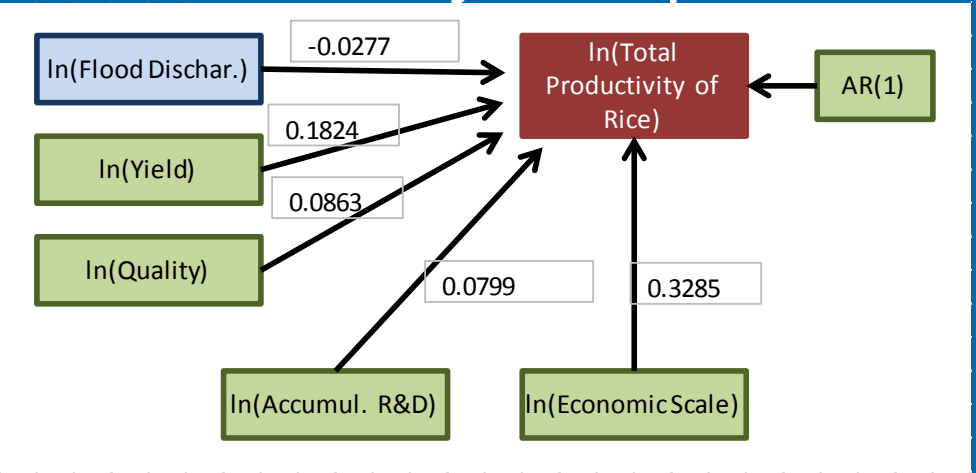
- Impact analysis on Foods in paddy-dominant areas
- Proposal of counter-measures [land use change (develop.), breeding, irrigation, water manag. etc.]
- Evaluation of effects of mitigation & adaptation methods in 'Food Politics'



AFFRC Water-Food Model

Measurement of Risks by a Socio-Economic Model

- A model to analyze impact factors in productivity（TFP)

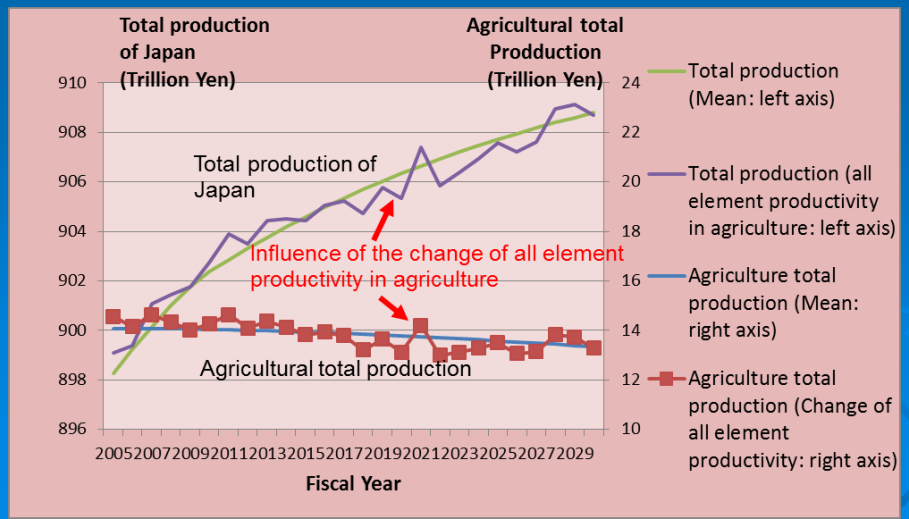


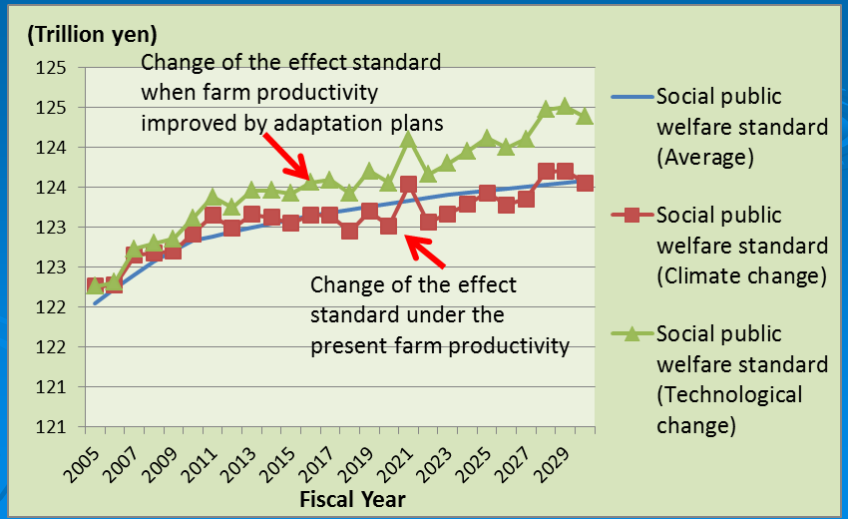
Parameters are the results estimated as paneled data (9 regions ×32 years).

Kunimitsu, etc. (in Print), *Paddy and Water Environment*

- Monte-Carlo simulation by an Applied General Equilibrium Model (a prototype)

Kunimitsu, etc. (2011) , *WIT Press*



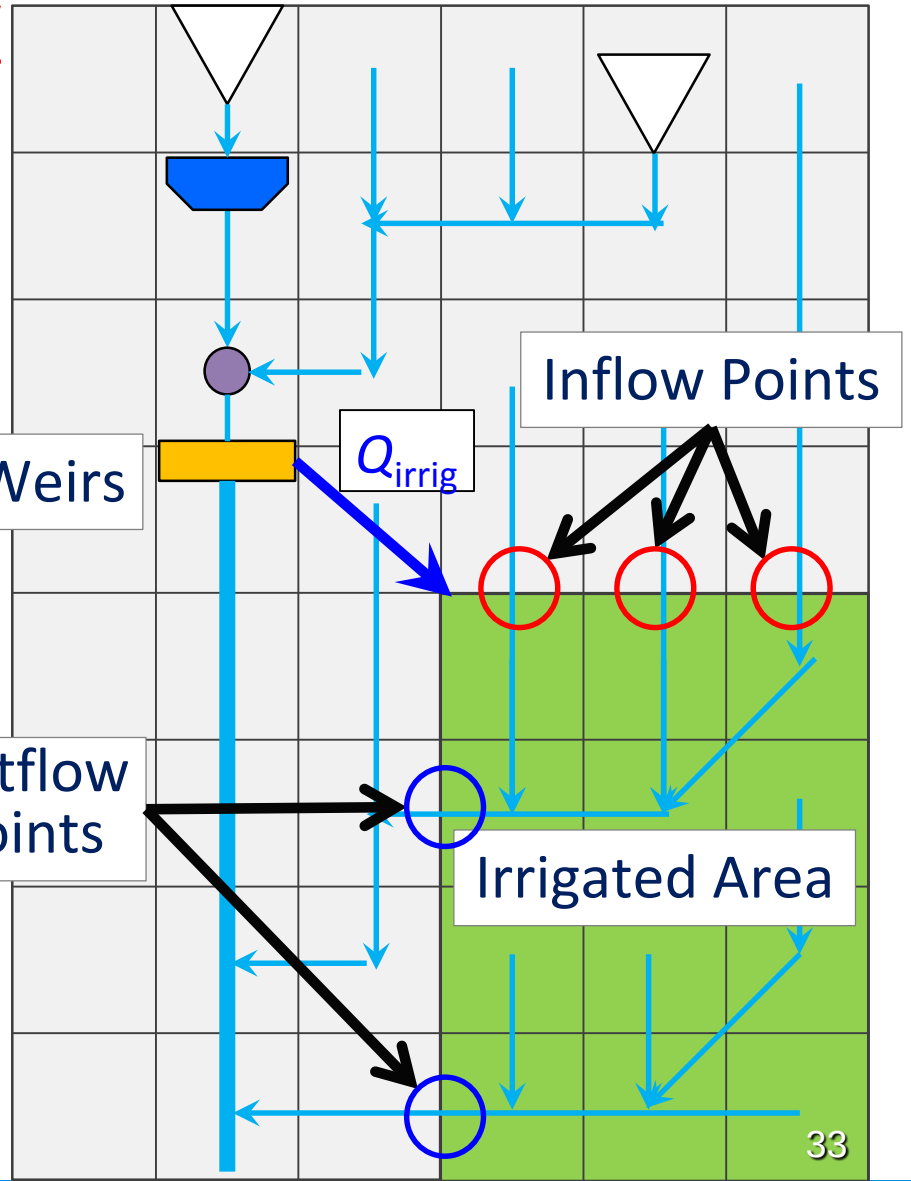


[Application 4] Issues on Agricultural Water Right

- Negos among Ministries

→ Needs for "Return-flow rate" estimation

Difficult to observe those, but possible to estimate through a model (DWCM-AgWU Model)



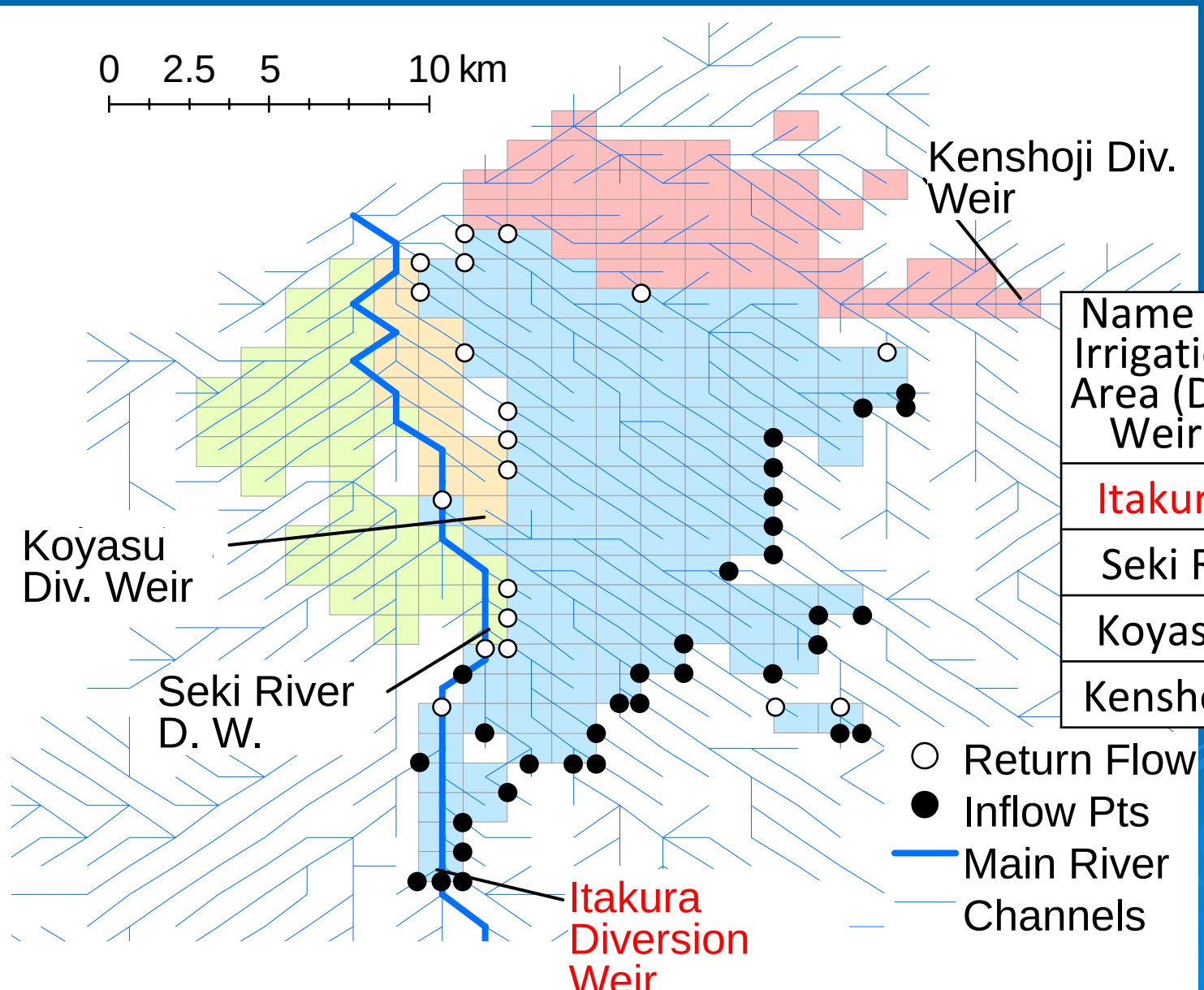
Searches for in/out-flow points

- Search an irrigation area for outflow pts.(◯) and inflow pts.(◯) from residual areas

Estimation of outflow amounts

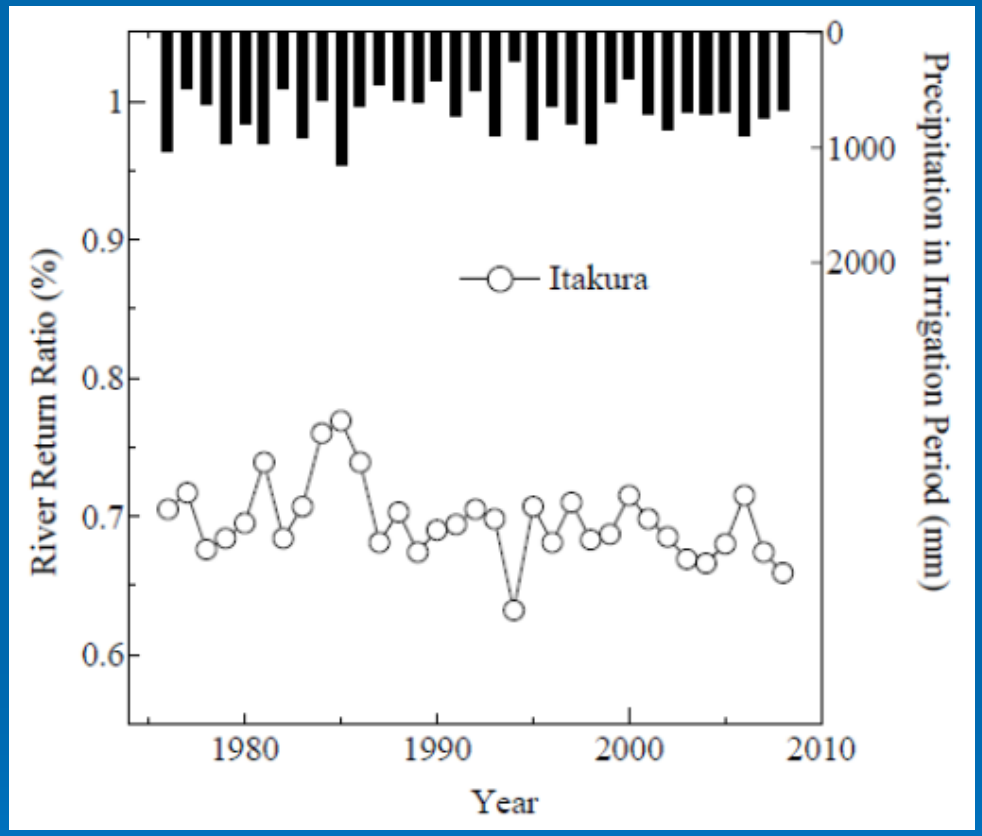
- Estimate **return flow rate** in an irrigation area

Estimation Example for Seki River Basin

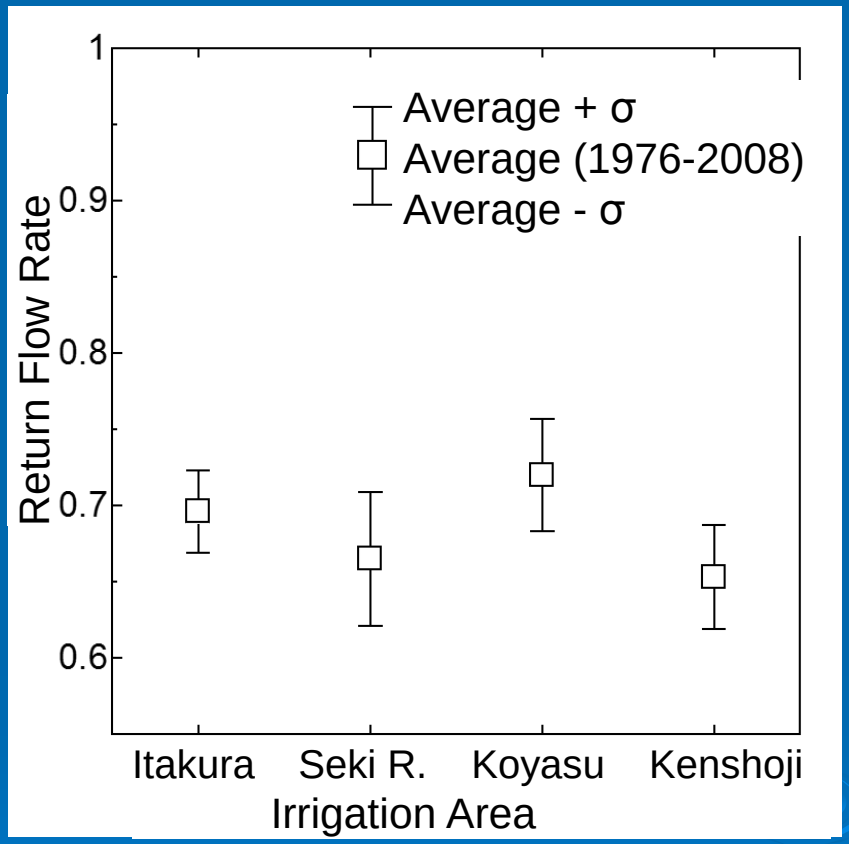


Name of Irrigation Area (Div. Weir)	In-flow pts. (●)	Out-flow pts. (○)
Itakura	33	21
Seki R.	25	8
Koyasu	11	5
Kenshoji	23	7

Estimated Results of River Return Flow Ratio



Annual change of return ratio



Comparison of return ratio in irrigated areas

- Return ratio is larger than expected.
  → Applicable to any river basin in Japan

[Application 5] ISO in Water Resources (Water Footprint)

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- Results of WF Inventory Analysis

Items	Unit Processes, ton/kg yield**	Ratio of Irrigation Water to Potential Water Availability ($R + Q_{irrig}$)	River Return Ratio ([Return to Rivers] /[Irrigated Water])*
Rainfall (R)	1.649	0.518 (0.735)	0.696
Irrigation water (Q_{irrig})	1.776 (4.593)		
Inflows from residual areas (Q_{res})	(6.491)		
Returns into rivers (Q_{return})	(11.410)		
Infiltration	1.158		
Evapotranspiration	0.946		

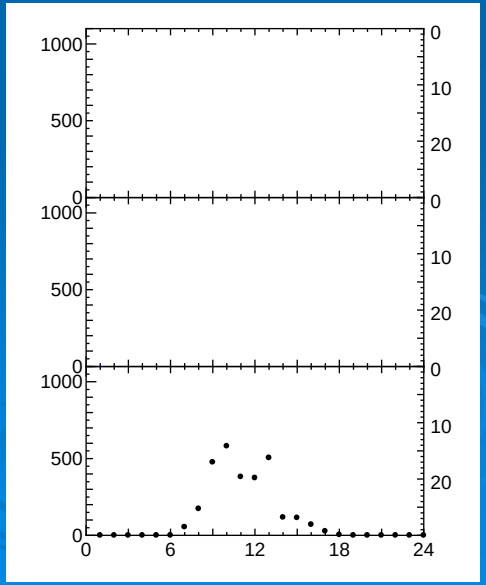
- Average for 33 yrs (1976–2008) of daily calculations, 76.3-km² irrigated areas

Leads to an application of【Visualization of Water Resources】

Part 3 Proposals for the Future Challenges in Agro-Environment Research

Challenging Research in the Future

- Mechanism →Climate and irrigation (the longer observation is, the more chances to discover new phenomena)
- Notion of a basin →Change of the concept of basins (ex.: upland agric. on the Kashima Plateau, aqua-research)
- Oversea assist. →Educational and technical assistance in Cambodia
- Extreme events →2011 Flood in Thailand (Seam-less model of irrigation and flood) →Exports of socio-infras
- Participatory disas. prev. →Practices for reducing floods by controlling irrigation gates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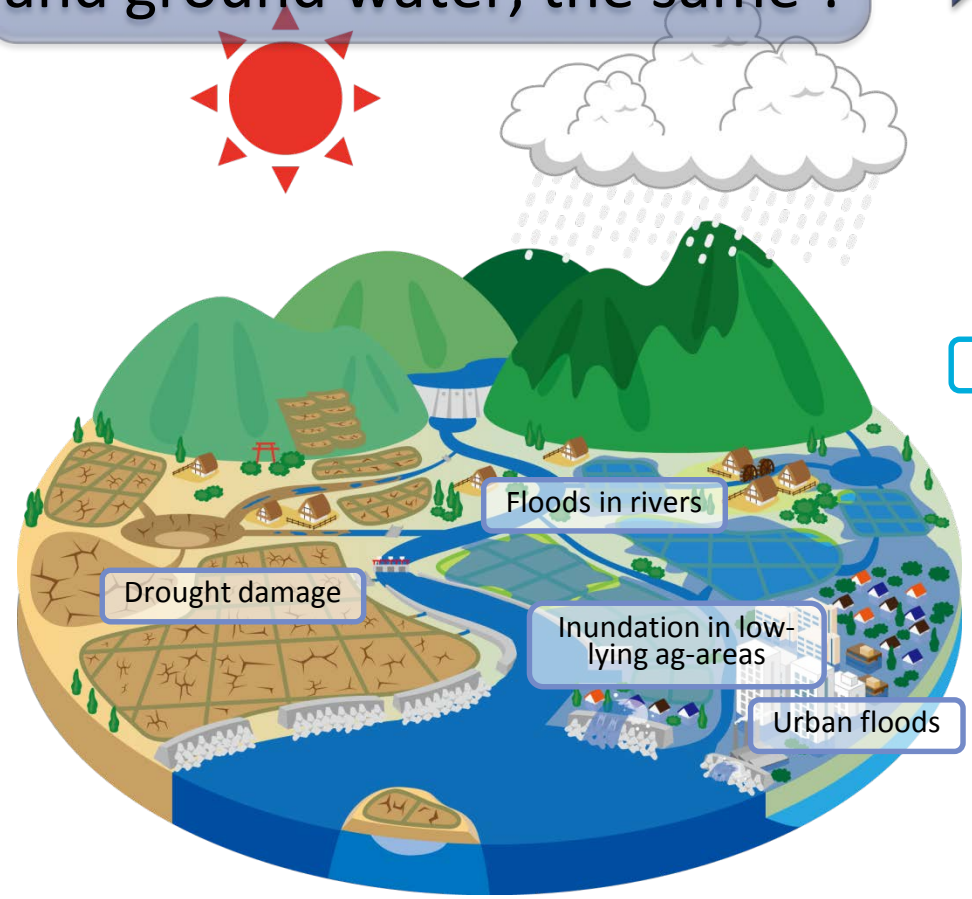
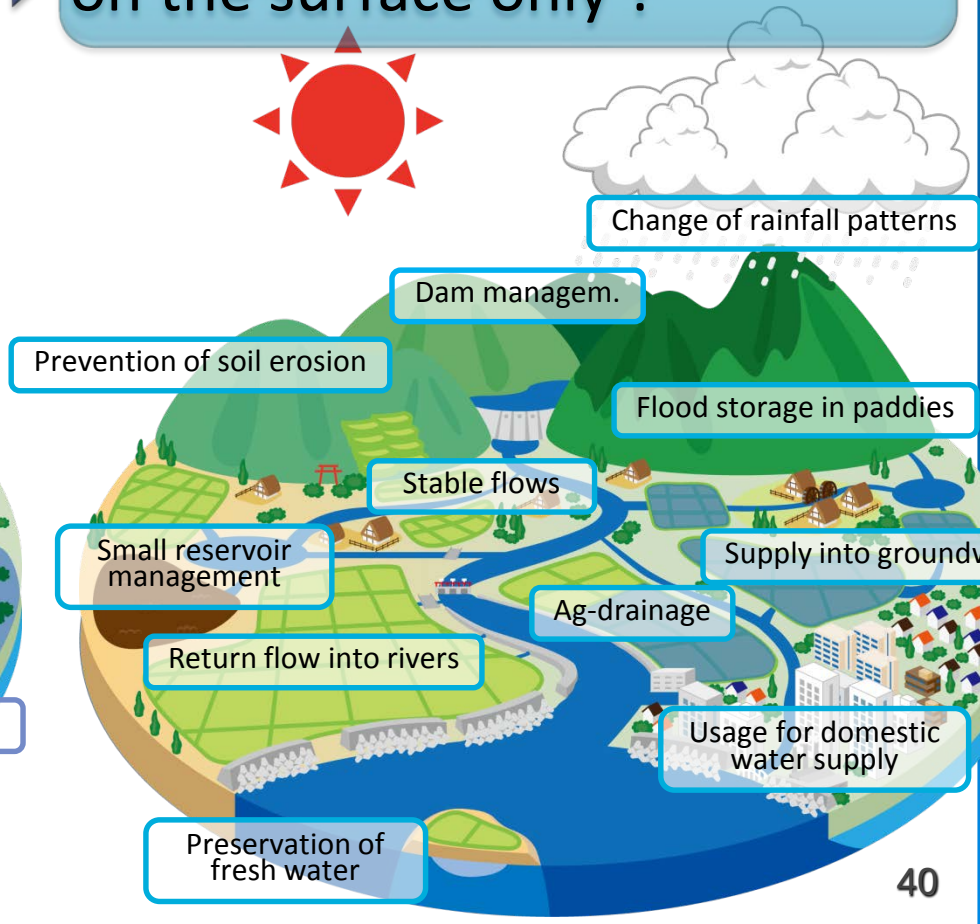
[Proposal 2] Concept of the Basin

- Paradigm Shift of "Basin" (Boundary for Ground Water and Fishery Research)

Under climate change, boundaries of surface water and ground water, the same ?

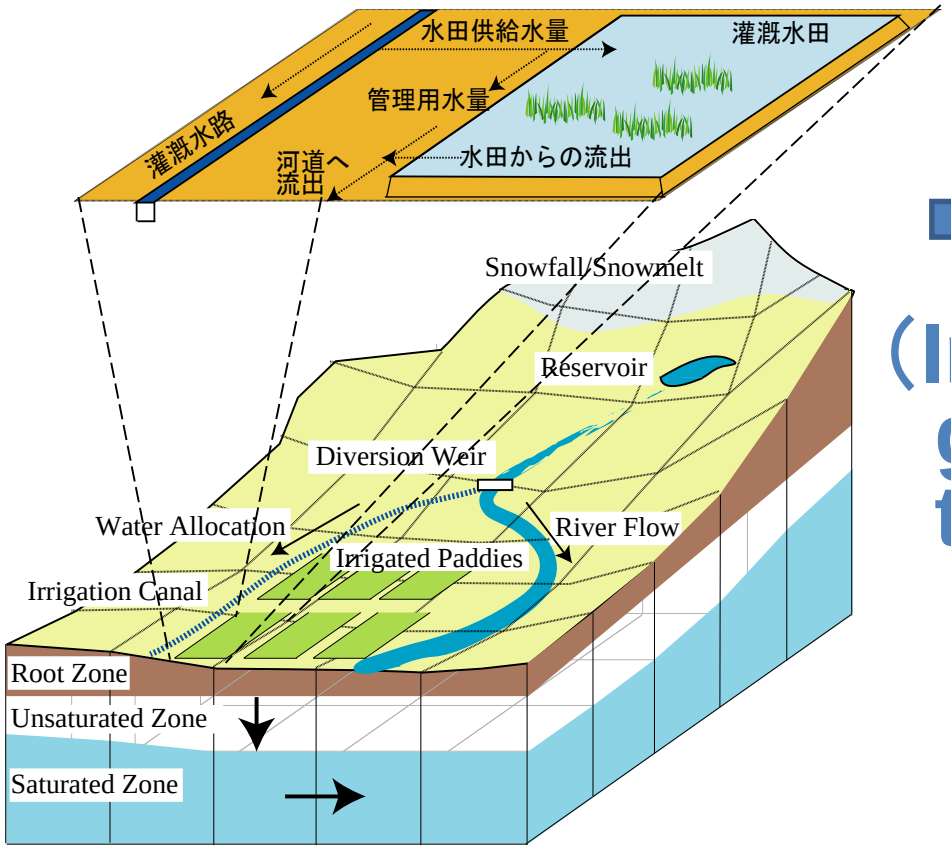
Future Earth: Realization of safe society, basin boundary on the surface only ?





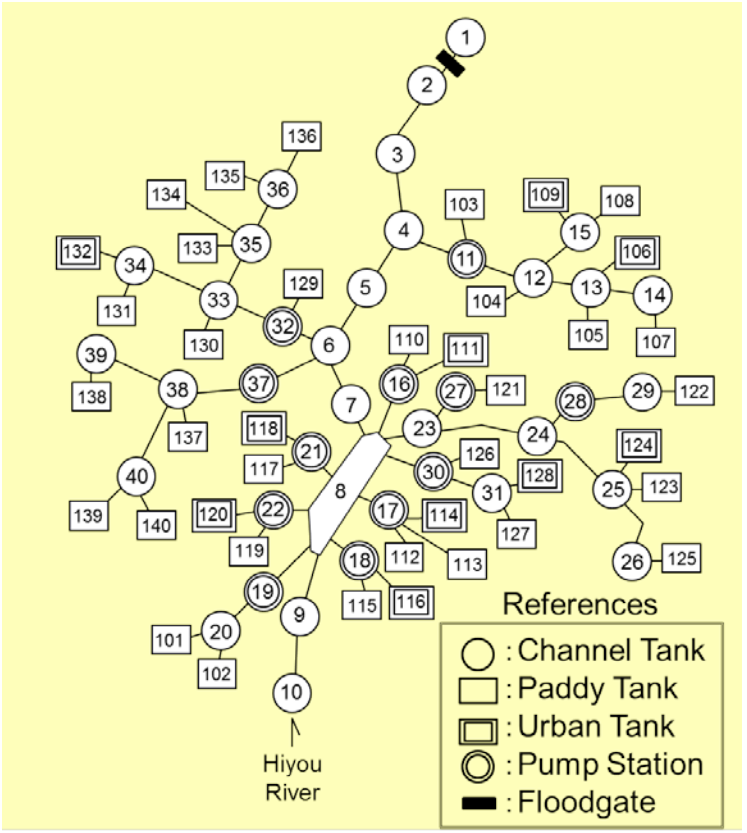
[Proposal 3] Development of a Seamless Model for the Analysis of Extreme Events

- Occurrence of 2011(2013, again) Chao Phraya River Flood → Seamless model for Irrigation & Flood → Export of a Rural Infrastructure (a package)



DWCM-AgWU Model

(Inte-gra-tion)



Regional Drainage and Inundation Model

Conclusion

1) To tackle with agro-environmental problems through "visualization" of water circulation

2) Methods: Obs. and modeling =[visualization]
Backgrounds: Big issues against agro-environments have occurred one after another as food, CC, energy, massive earthquakes, etc.

→ Do not live against ***the tides of the times***!

Contents: Application 1), 2), 3), ・・・
Proposal 1), 2), 3), ・・・・・

→ ***Seamless treatment*** in irrigation and flood!

The End

Thank you for your attention.