A global water scarcity assessment under Shared Socio-economic Pathways

Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., Kainuma, M., Kanamori, Y., Masui, T., Takahashi, K., and Kanae, S

Outline

Two papers were submitted to Hydrology and Earth System Sciences.

Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., Kainuma, M., Kanamori, Y., Masui, T., Takahashi, K., and Kanae, S.: A global water scarcity assessment under Shared Socio-economic Pathways: Part 1 Water use, Hydrol. Earth Syst. Sci., 2012.

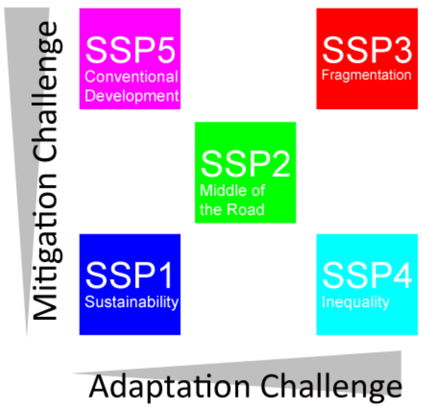
Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., Kainuma, M., Kanamori, Y., Masui, T., Takahashi, K., and Kanae, S.: A global water scarcity assessment under Shared Socio-economic Pathways: Part 2 Water availability and scarcity, Hydrol. Earth Syst. Sci., 2012.

Draft papers are available (hard/soft copy) .

Shared Socio-economic Pathways

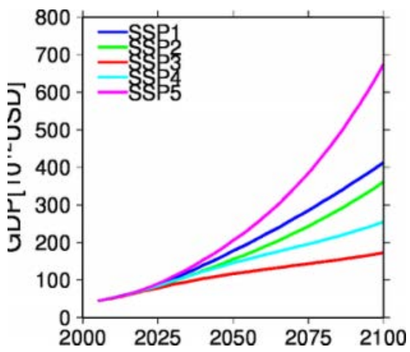
SSPs: New socio-economic scenarios for global change study (post SRES)

SSP	Description
SSP1	Sustainability
SSP2	Middle of the Road
SSP3	Fragmentation
SSP4	Inequity
SSP5	Conventional Development

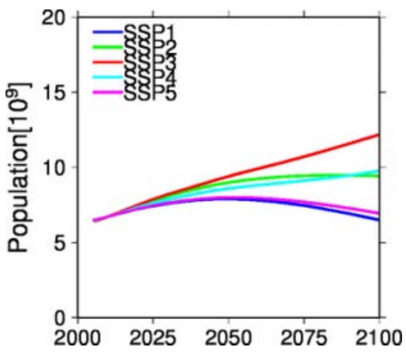


Similar to SRES, major socio-economic factors are quantitatively available

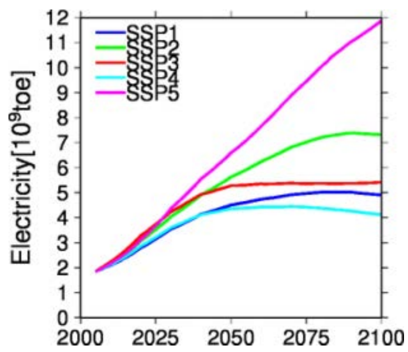
GDP (global total)



Population



Electricity production



How people use water in each SSP?

Almost no description on water use in qualitative/narrative scenarios of SSPs
→ Tried to develop a water use scenario COMPATIBLE with SSPs.

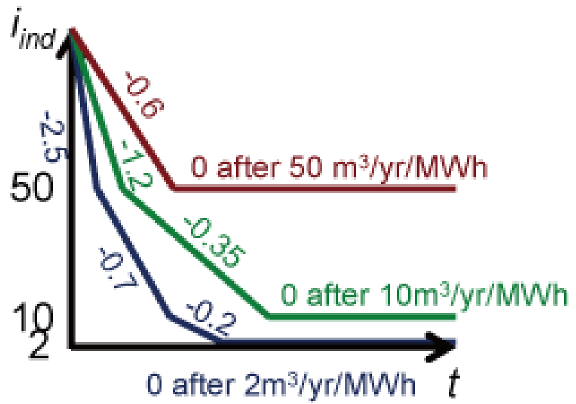
1. Developed simple (but robust) models on water use

$$IndustrialWater = Electricity \times intensity$$

- Electricity: Quantitative scenarios from SSPs
- intensity: Scenario-dependent parameter

2. Developed THREE parameters for each model INDEPENDENTLY from SSPs

Ex: Scenarios on industrial water intensity



- Low efficiency
- Mid efficiency
- High efficiency

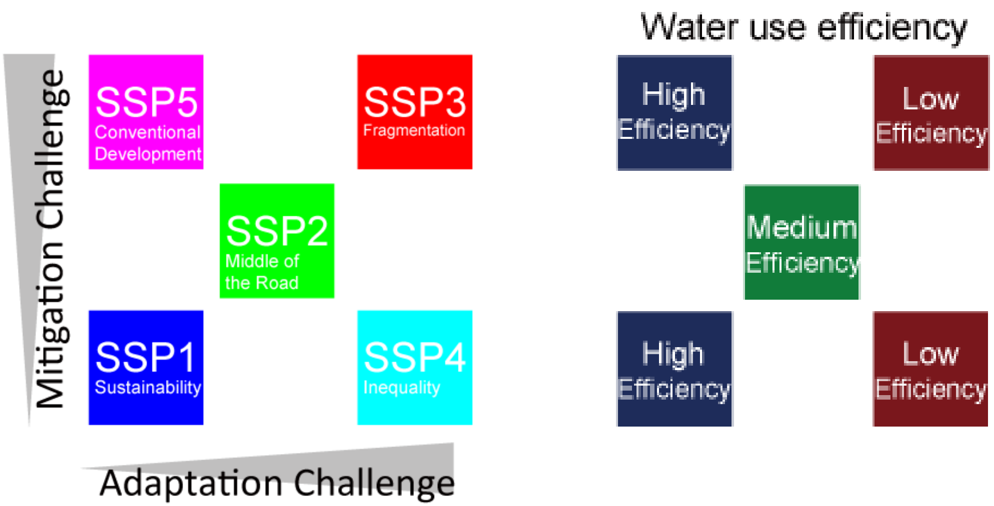
Rate historically observed in China/Thailand, Japan, and Israel

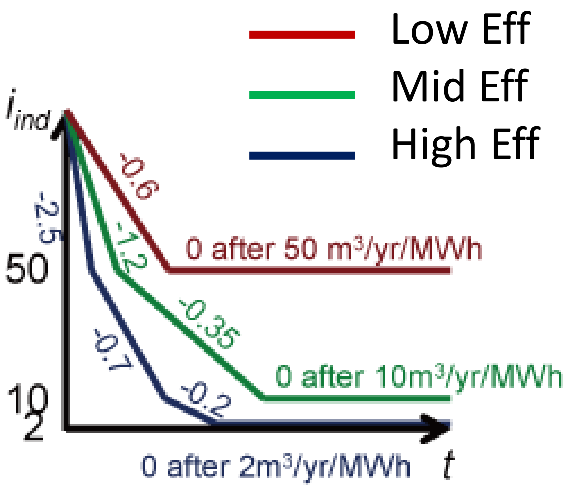
How people use water in each SSP?

3. Linked three parameters and five SSPs focusing on narrative scenarios

SSP	Description	Technological change
SSP1	Sustainability	Rapid
SSP2	Middle of the Road	Moderate
SSP3	Fragmentation	Slow
SSP4	Inequity	Rapid/Slow
SSP5	Conventional Development	Rapid

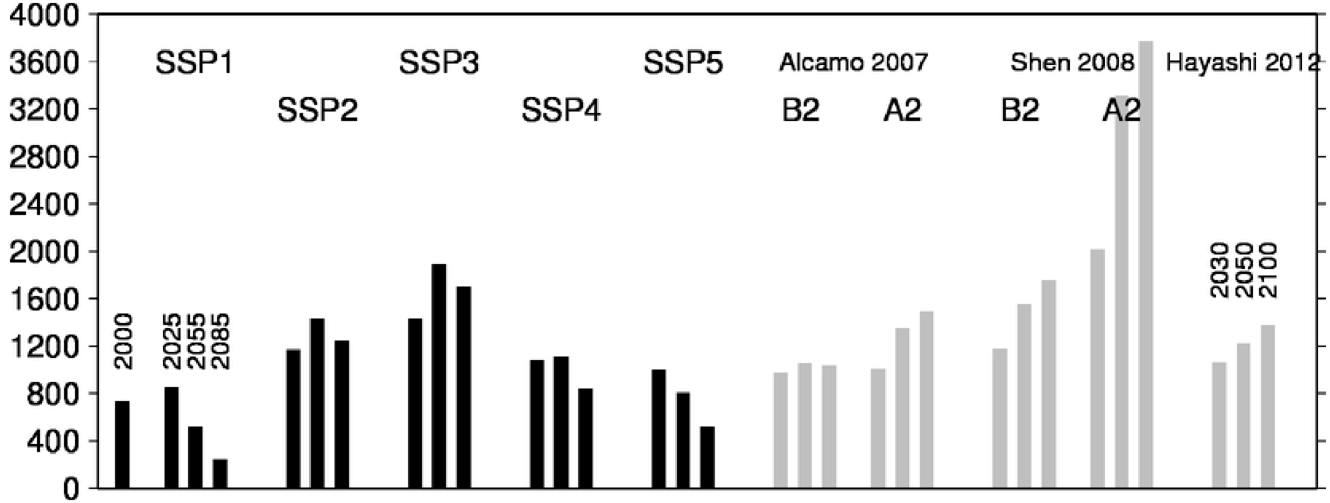
$$IndustrialWater = Electricity \times intensity$$



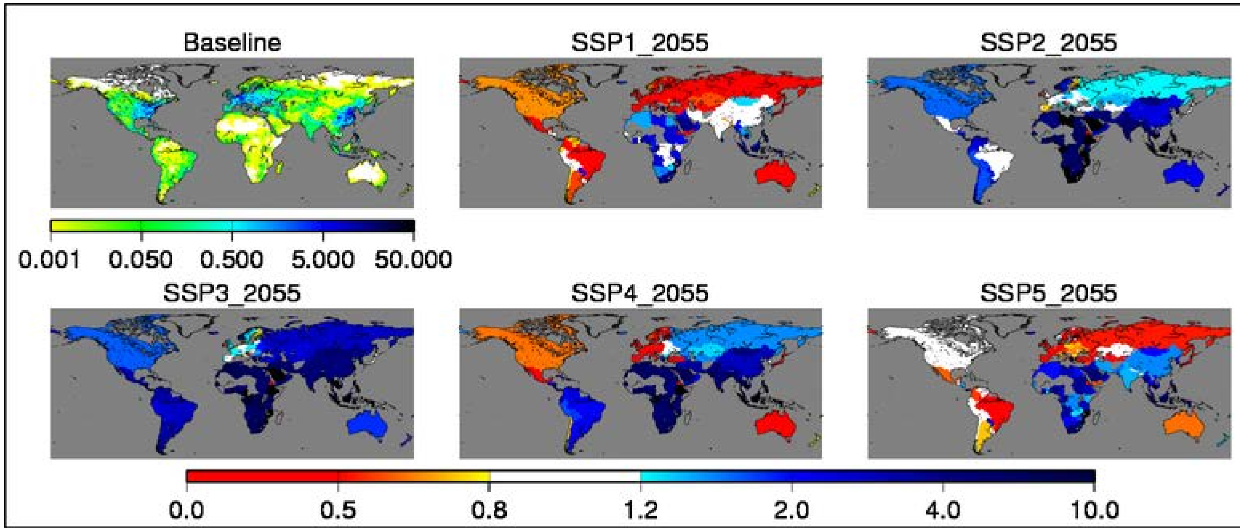


Water use scenarios

Global total industrial water withdrawal

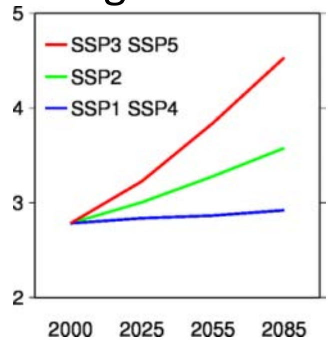


Change in industrial water withdrawal (2055 - 2000)

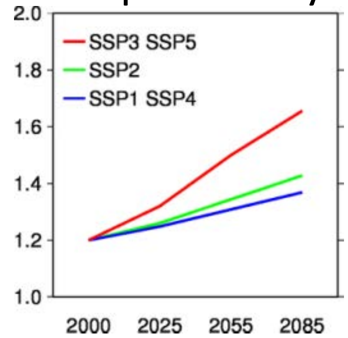


Water use scenarios

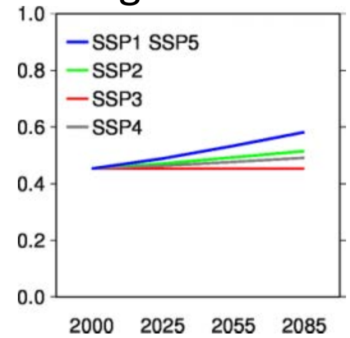
Agricultural scenarios: Irrigation area



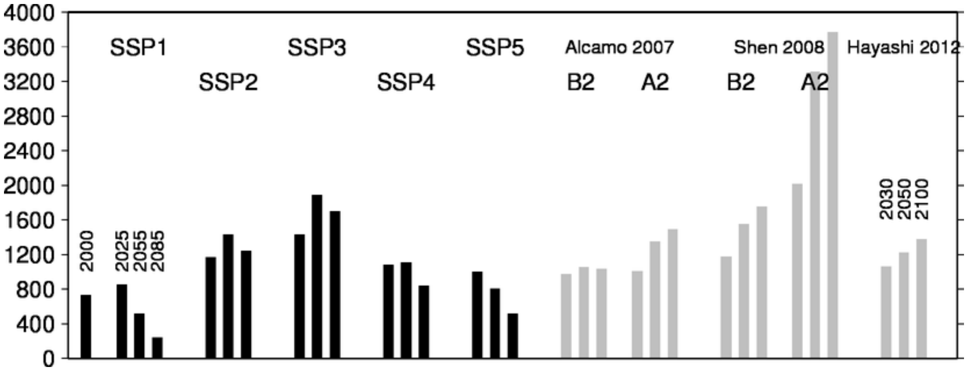
Crop intensity

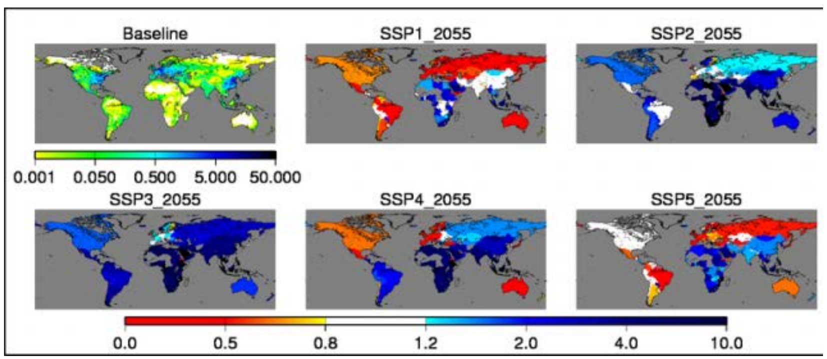


Irrigation efficiency

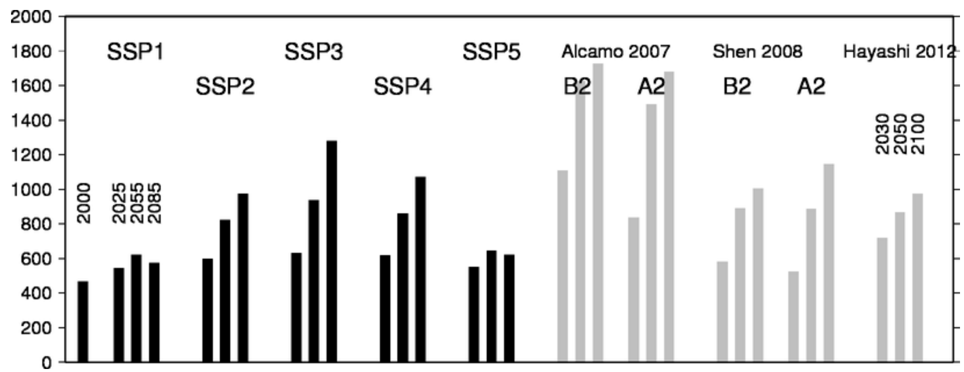


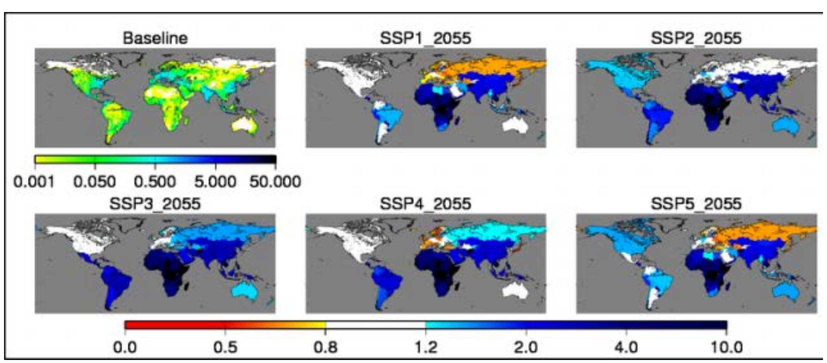
Industrial water withdrawal scenarios





Domestic water withdrawal scenarios





Is water available?

In Part 1 “potential water demand” was projected.
→ Investigated the projected amount of water is hydrologically available.

What would be the future climate?

Scenario matrix

	RCP2.6	RCP4.5	RCP6.0	RCP8.5
SSP1	SSP1 policy		SSP1 BAU	
SSP2		SSP2 policy		SSP2 BAU
SSP3			SSP3 policy	SSP3 BAU
SSP4	SSP4 policy		SSP4 BAU	
SSP5			SSP5 policy	SSP5 BAU

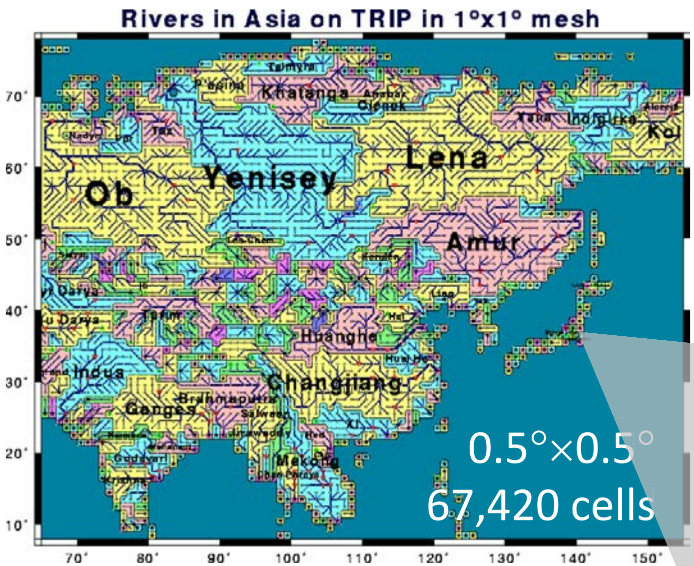
GCM

MIROC-ESM-CHEM
HadGEM2 ESM
GFDL ESM2M

Time

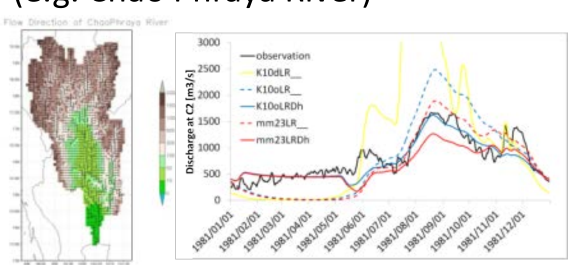
1971-2000 (base period)
2011-2040
2041-2070
2071-2100

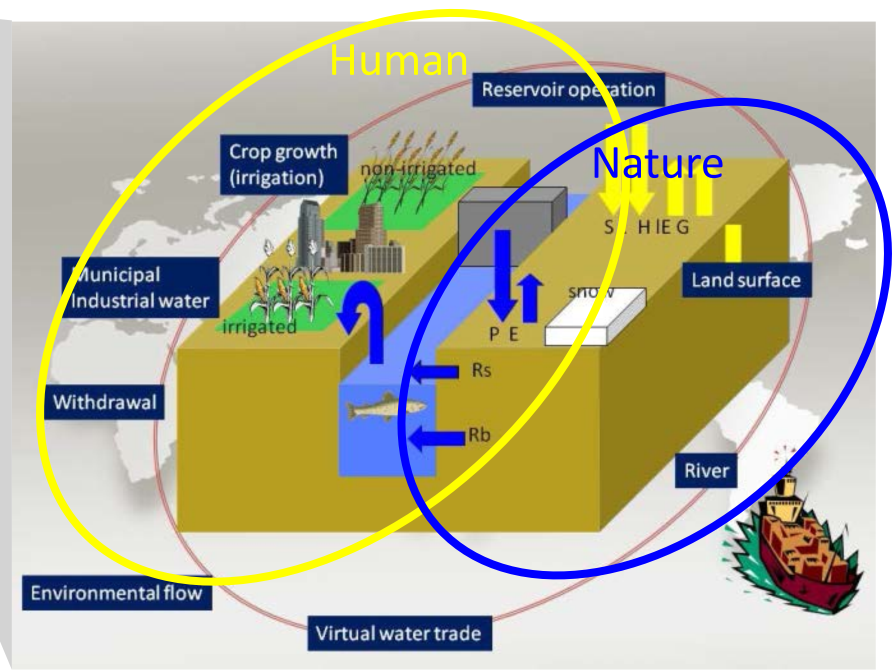
Global water resources model H08



1. High spatial resolution (0.5°×0.5°)
2. High temporal resolution (daily)
3. Interaction between natural water cycle and human activities

Regional simulation
(e.g. Chao Phraya River)

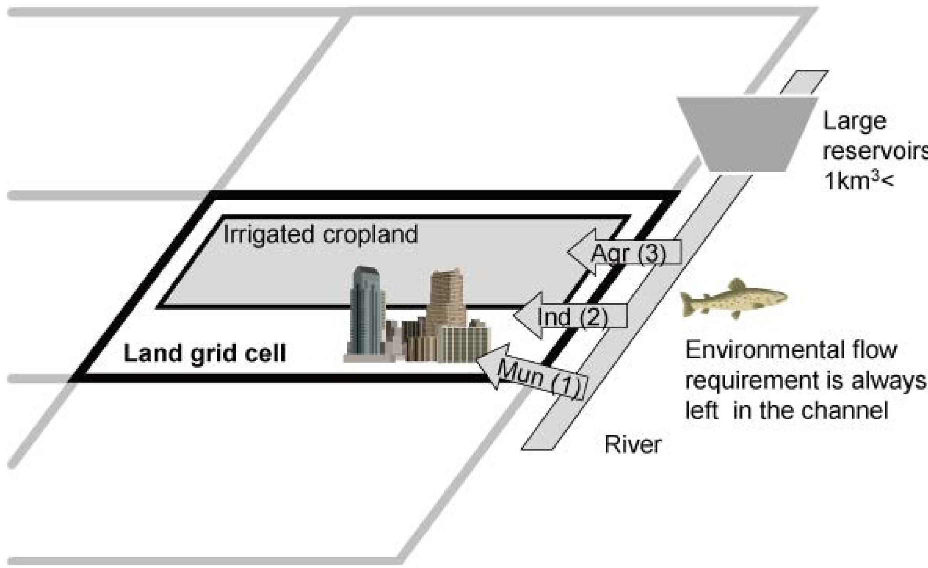




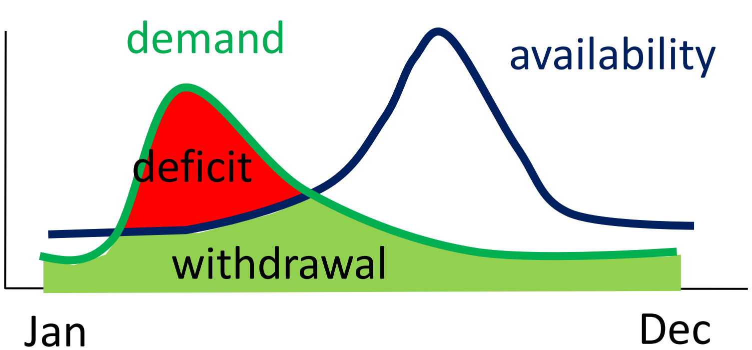
How can we know “water scarcity”

Method used in this study

Water withdrawal simulation
- Withdraw from river
- Daily interval
- Rivers can be depleted, and withdrawal can fall below demand



$$CWD = \frac{\sum_{DOY=1}^{365} withdrawal_{DOY}}{\sum_{DOY=1}^{365} demand_{DOY}}$$

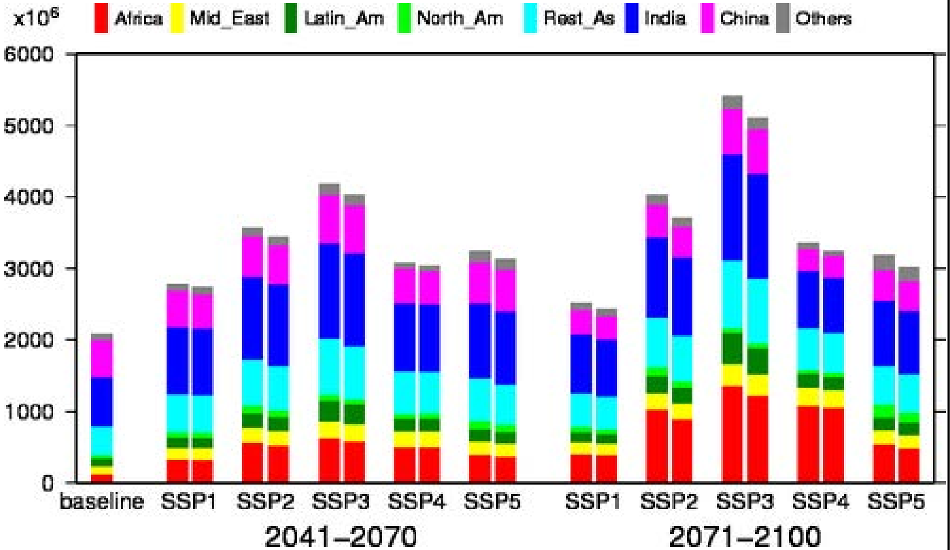


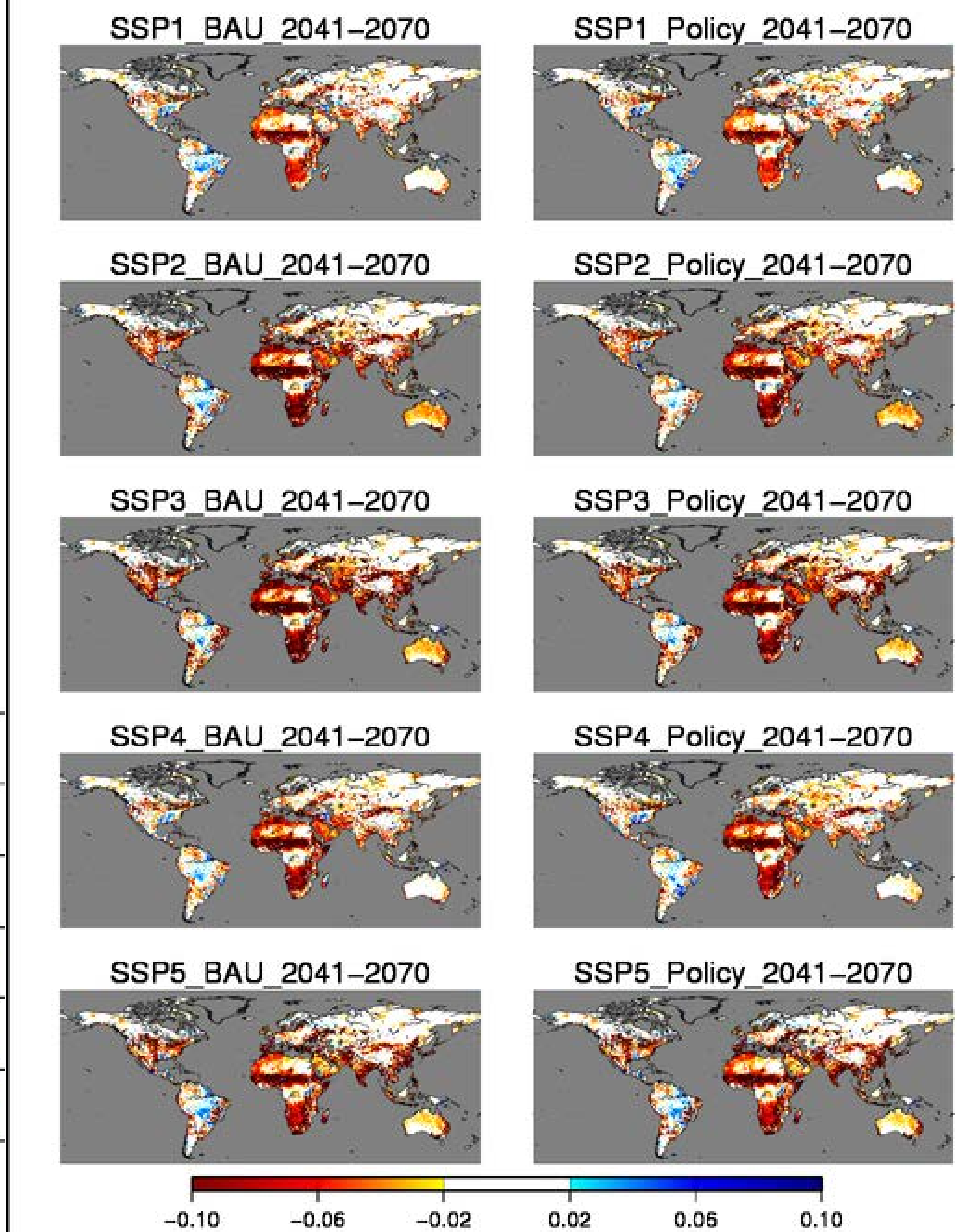
Water scarcity: CWD<50%

Water scarcity assessment

Change in CWD ratio
→Stress increases including regions mean annual runoff increases
→ Climate policy has limited effect for overall structure of water scarcity?

Stressed population
→Population living in grid cells with the condition of CWD < 50%





Summary

Developed water use scenario compatible with SSPs.
Assessed water availability and use globally.
As far as we know, this is the first such study.

Two papers will be soon available online as discussion paper.
→ During Open Discussion period, anyone can comment to these paper.

Next steps
- Adaptation options
- Working together with AIM/CGE

Next steps with YOUR help
- Better water use scenario (historical data, evaluating technical feasibility)
- Further nexus (mitigation, LCS, land use, agriculture studies, and more)

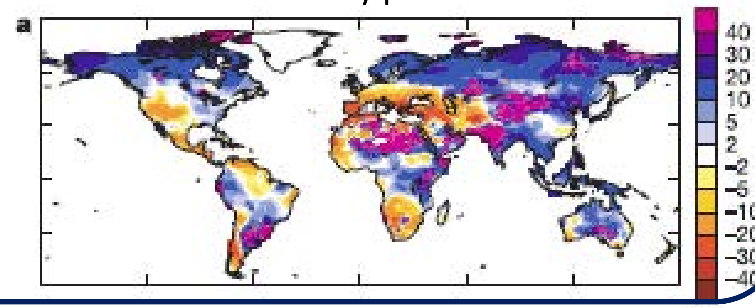
Why don’t you use WWR index?

Conventional method

$$WWR = \frac{AnnualWithdrawal}{AnnualRiverDischarge}$$

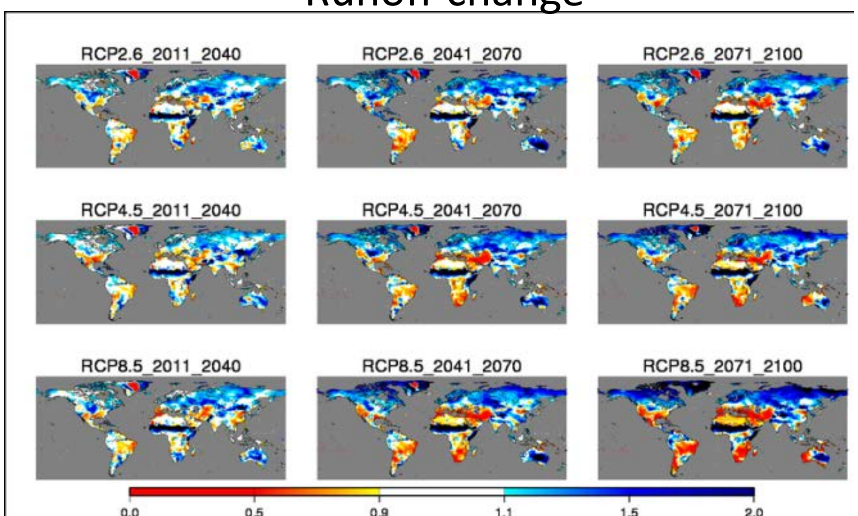
Water scarcity: WWR>40%

Annual river discharge change
→ Increases in many parts of the world

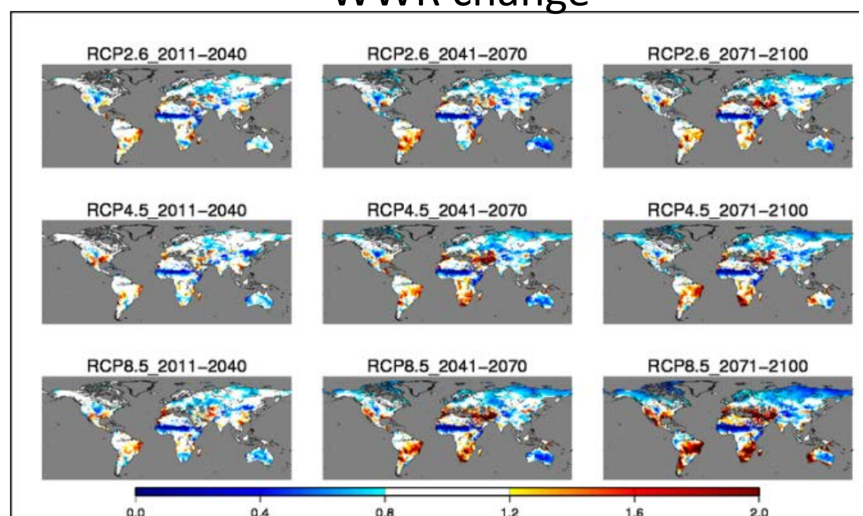


Sometimes misleading results: where mean annual runoff increases, WWR automatically decreases (indicating water scarcity is alleviated)

Runoff change



WWR change



Climate policy has only little effect?

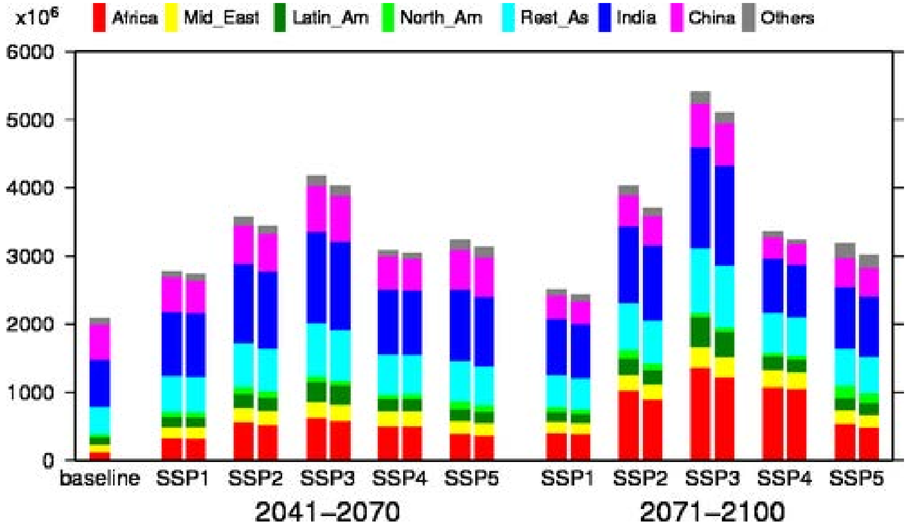


Figure 15 Region-wise total global population living in grid cells where CWD < 0.5. The bars in left and right show the results of no climate policy and with climate policy respectively.

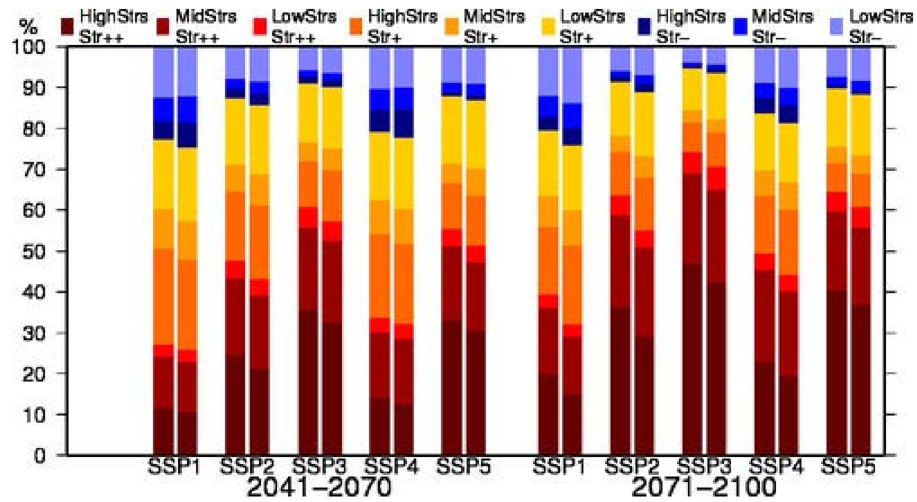


Figure 16 Percentage of global population living in grid cells categorized as Significant Degradation (ΔCWD<-0.05, red), Moderate Degradation (-0.05≤ΔCWD<0, orange), and Alleviation or no change (0≤ΔCWD, blue). Each category was subdivided into three by the change in the CWD recorded as Highly Stressed (CWD<0.5, dark), Moderately Stressed (0.5≤CWD<0.8, medium), and Less Stressed (0.8≤CWD, pale). The bars in left and right show the results of no climate policy and with climate policy respectively.