Global Estimation of the Synergies and Trade-offs among Climate Policies and SDGs in terms of Water Sector
気候政策が水に関するSDG目標へ与えるグローバルな影響

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Background

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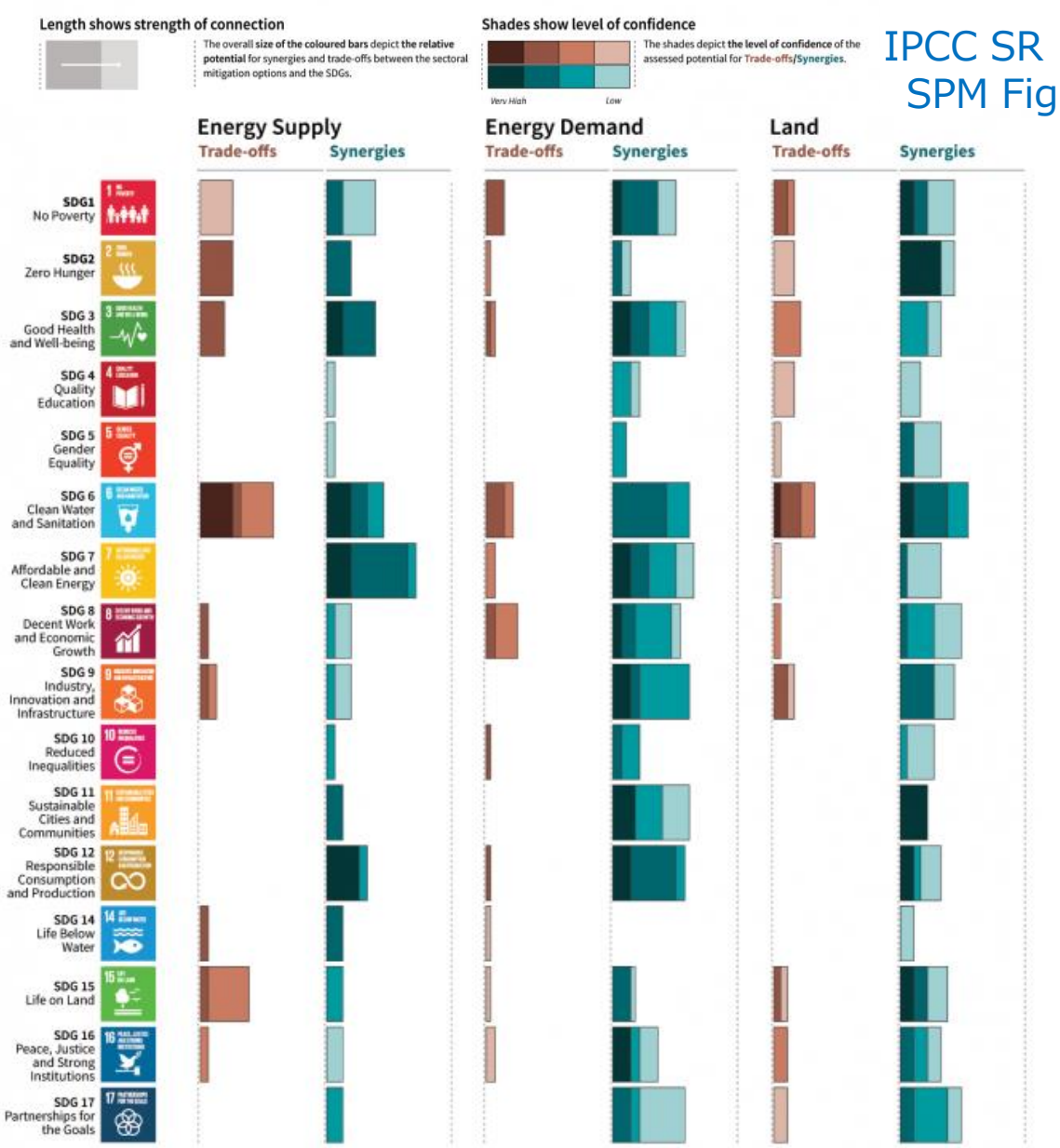


IPCC SR 1.5
SPM Fig.4

- Climate change mitigation and adaptation measures are expected to have significant synergies with efforts to achieve the Sustainable Development Goals (SDGs); however, trade-offs are also a concern.
- SDG 6 (water) exhibits the greatest trade-offs through energy demand and land use.
  - ✓ The assessment of past IPCC reports are mainly based on a qualitative review
  - ✓ IPCC SR Land (2019) assess the qualitative effects of biofuel production
  - ✓ The integrated assessment model lacks consideration of water resource constraints, drought, and flooding.
- Quantitative effects of climate actions (mitigation & adaptation) to SDG targets

There is great synergy between mitigation and adaptation measures to improve vulnerability to fluvial flooding

- Low emission scenario can reduce the deterioration of the SDG indicator by up to 50% by 2100 compared to the high emission scenario, with mitigation measures having greater synergy.
- Adaptation measures can reduce the deterioration of indicators by 19%.
- With financial support from outside their own countries, exposure to flooding in low-income countries can be reduced from current levels.
- More ambitious flood control measures are also important to achieve flood exposure indicators in low-income countries to levels similar to those in developed countries.

Changes in SDG 1.5.1 (poverty) and SDG 11.5 (urban) indicators (flood exposed population per 100,000) for fluvial flooding. Standard adaptation: a country protects up to if costs is lower than benefits; maximum adaptation: a country adapts when adaptation is effective regardless of costs of the additional protection.

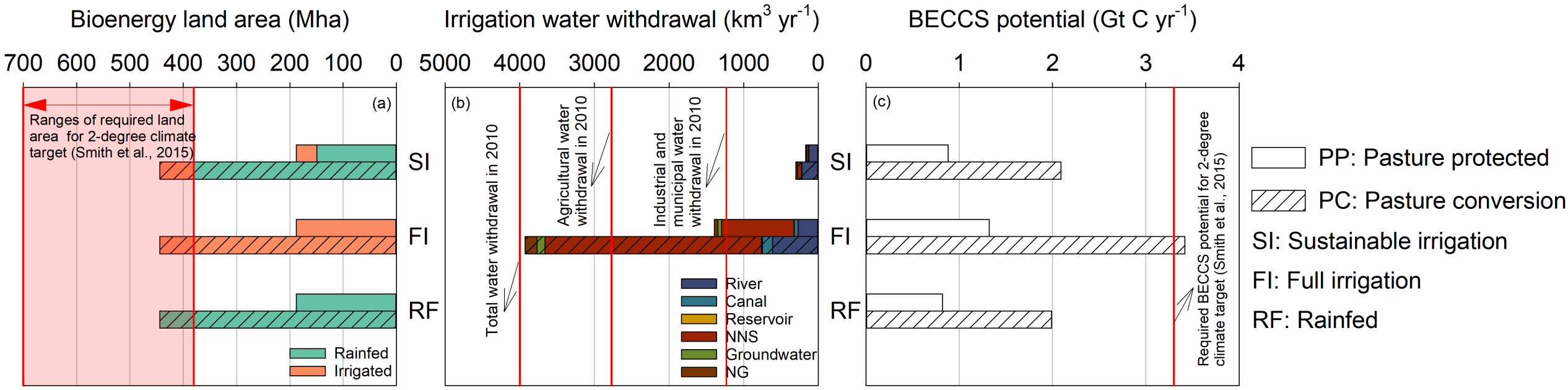
Effect of Mitigation	Current Climate	2030	2050	2100
Low emission (ssp126)	4.55	5.56 (+1.01)	5.85 (+1.30)	5.55 (+1.00)
		-0.65	-1.03	-2.26
High emission (ssp585)	4.55	6.21 (+1.66)	6.88 (+2.33)	7.81 (+3.26)

Effect of Mitigation	Current Climate	2030 Without adaptation	2030 Standard adaptation	2030 Maximum adaptation
Low-income countries (ssp585)	4.55	6.21 (+1.66)	-0.88 5.33 (+0.78)	-3.12 3.09 (-1.46)
High-income countries (G7) (ssp585)	1.01	1.48 (+0.47)	-0.01 1.46 (+0.45)	-0.37 1.11 (+0.10)

Tanoue et al., Nature Climate Change, 2021

Neglecting water use sustainability could increase century-end global BECCS potential via irrigation by 60-71%, compared to a mere 5-6% when considering it

Maximum feasible amount of BECCS with sustainable irrigation



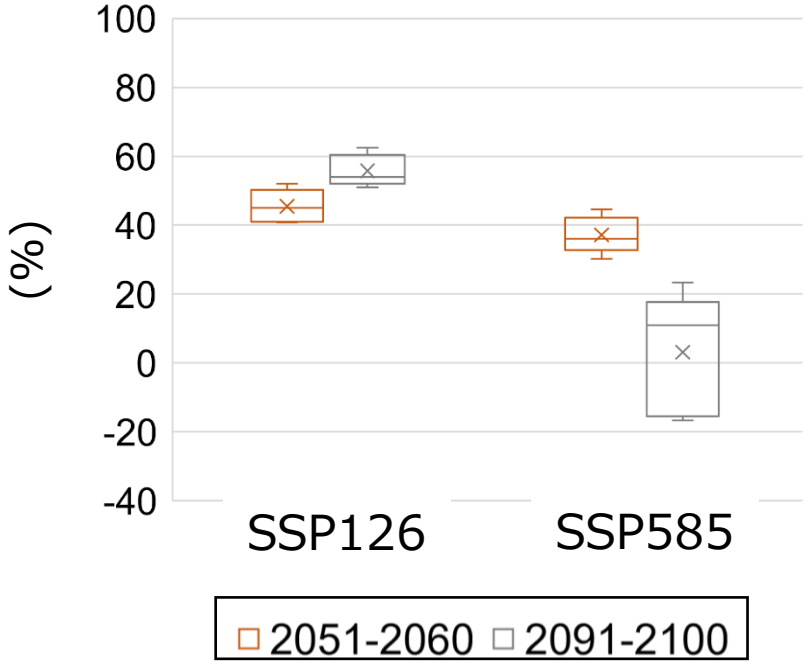
Sustainable irrigation increases BECCS maximum feasible volume by only 5-6%.
→Refute the optimism of conventional irrigation to increase BECCS production.

Ai, Hanasaki, et al., Nature Sustainability, 2021

Mitigation has a positive impact on small farmers' productivity (SDG2)

- Small farmers' productivity at the end of the century under the low emission scenario (ssp126) is 52.7% higher than under the high emission scenario (ssp585). →Mitigation has synergy to SDG2.
- The irrigation adoption rate in low-income countries in water scarce areas is 37% for small-scale farmers and 42% for non-small-scale farmers.
- 5% increase in the irrigation adoption, the small farmers' productivity can increase by 10% even ssp585. → importance of narrowing the gap in irrigation adoption rates in low-income countries

Change in annual agricultural output per household from current climate

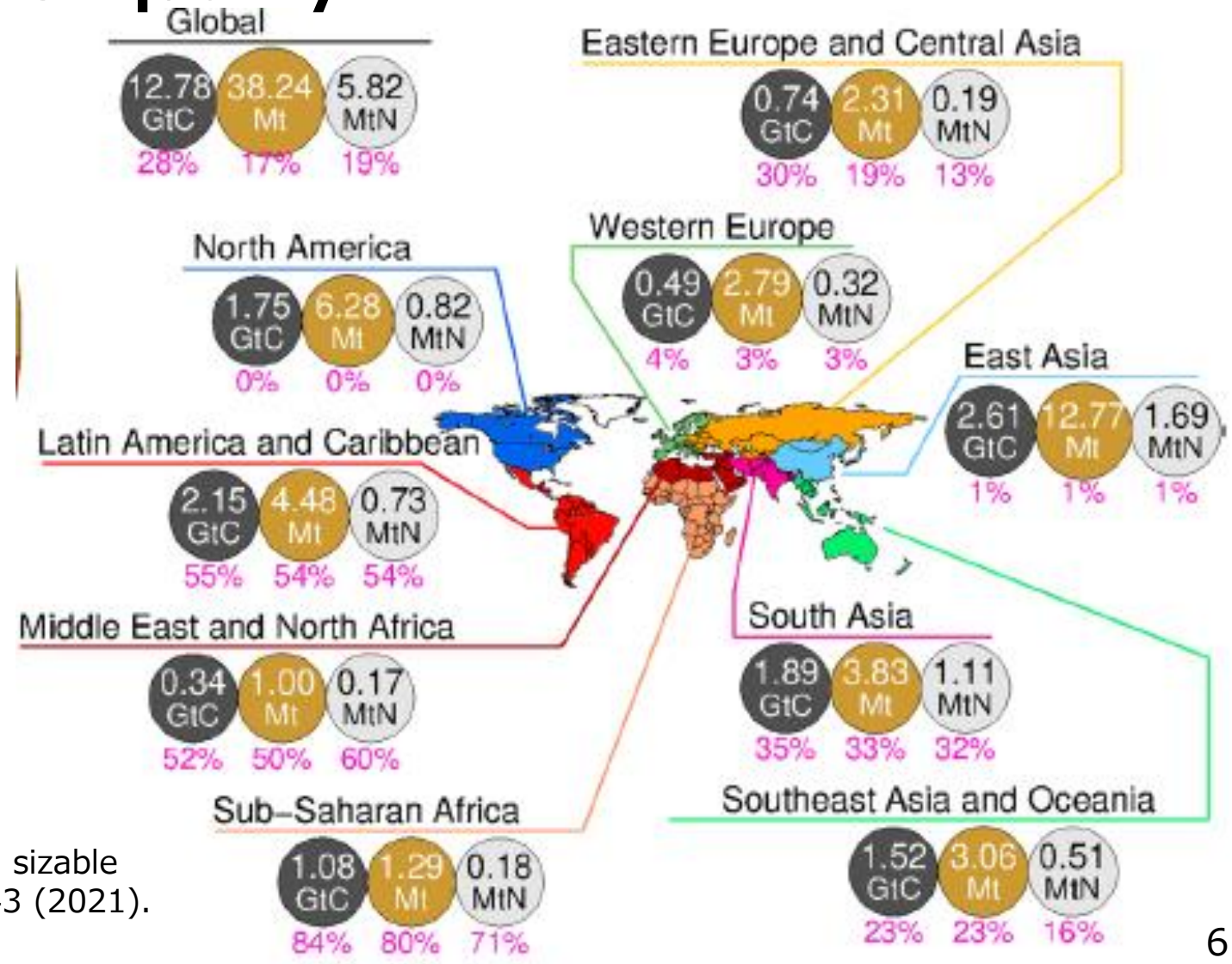


Change in annual agricultural output per household from current irrigated area

Nozaki et al. (2023), *Environ Res Commun.*

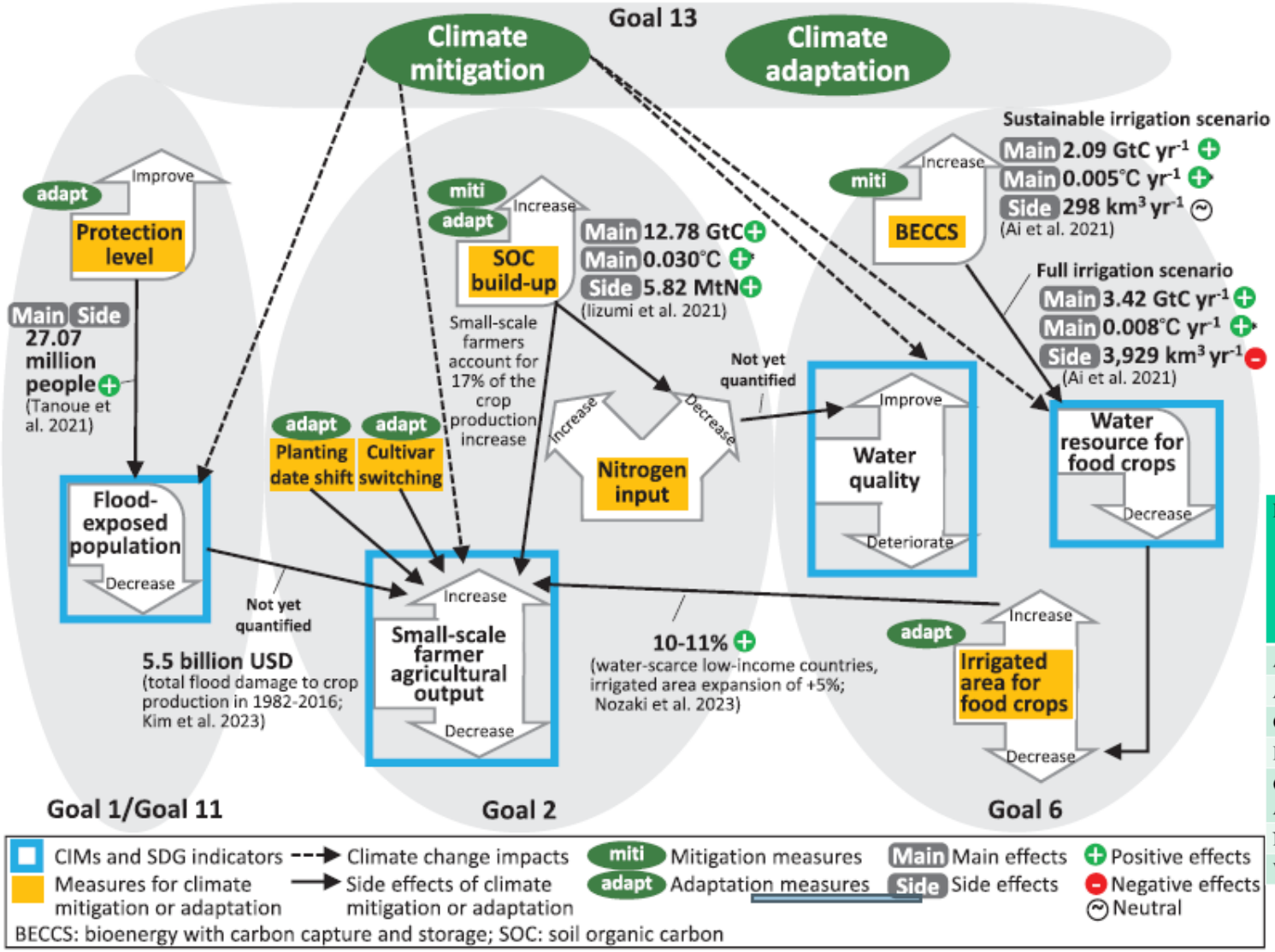
In addition to mitigation, carbon storage in agricultural lands is expected to have synergies in increasing crop yields and improving water quality

- Agricultural land management can increase global cropland soil carbon by 12.78 billion tC (11.55-14.05 billion tC).
- This amount of carbon could increase crop production by 38.25 million tons (22.88-5.748 million tons), reduce the global average temperature increase by 0.030°C (0.019-0.041°C), and save 5.82 million tons N (3.89-7.14 million tons N) in nitrogen fertilizer inputs.



Iizumi T, Hosokawa N, Wagai R Soil carbon-food synergy: sizable contributions of small-scale farmers *CABI Agric Biosci* **2** 43 (2021). https://doi.org/10.1186/s43170-021-00063-6

Promoting BECCS relying on too much water use may prevent a reduction in the disparity in the rate of irrigation adoption by small farmers



- If energy crops were fully irrigated, the increase in water withdrawal would be 3,929 km3 per year. This increase in water withdrawal is equivalent to 4,001 km3 of total global water withdrawal in 2010.
- In Asia and Africa, this would require 20 to 21 times more water than would be needed if competition with other water uses were avoided, and there is clearly no room for increasing the rate of irrigation adoption by small farmers.

Region	Increase in agricultural output of small farmers in low-income countries in water scarce areas if irrigated area is increased by 5% from current (%)	Additional water withdrawal for bioenergy crops km^3 yr^{-1} A: Full irrigation	Additional water withdrawal for bioenergy crops km^3 yr^{-1} B: Sustainable irrigation	A/B
Asia	13-17	784	40	20
Africa	4-11	1,089	52	21
Oceania	-	100	2	50
Europe	-	485	100	5
Central and South America	-	1,113	83	13
North America	-	306	19	16
World	10-11	3,929	298	13

Nozaki N et al. *Environ Res Lett* (2023)

Weather-related Disaster Risk and Tipping

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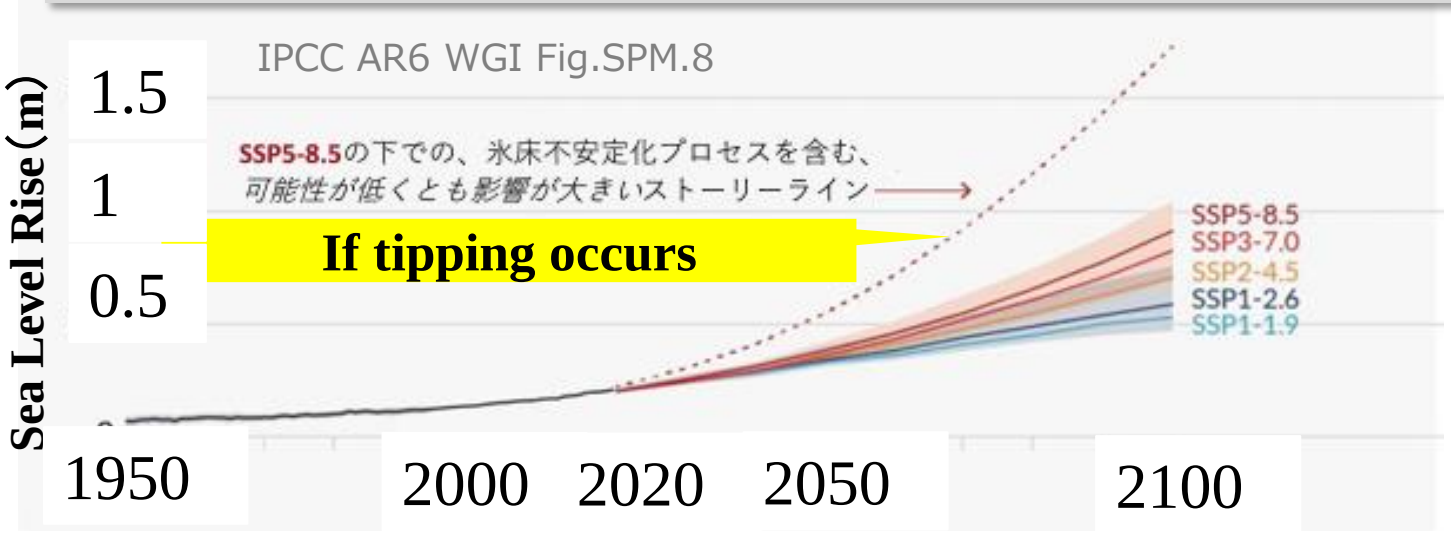
Climate change will increase the risk of weather-related disasters

Flooding in Rojana Industrial Estate, Thailand (Oct-Nov 2011)
タイ、ロジャナ工業団地の浸水
Source：MLIT

Increase in heavy rainfall, flooding, extreme temperature
大雨・河川洪水
極端な高温の増加

＋ **AR6 mentions qualitative impact of TE for the first time**
The higher, the greater the probability of occurrence.

Catastrophic Effects of Tipping Element (TE)



Most megacities are located along the coast

TE: Geophysical critical phenomena: irreversible changes that occur when a certain threshold (tipping) is exceeded

What happens if tipping should occur?

Collapse of ice sheet, increased fresh water supply

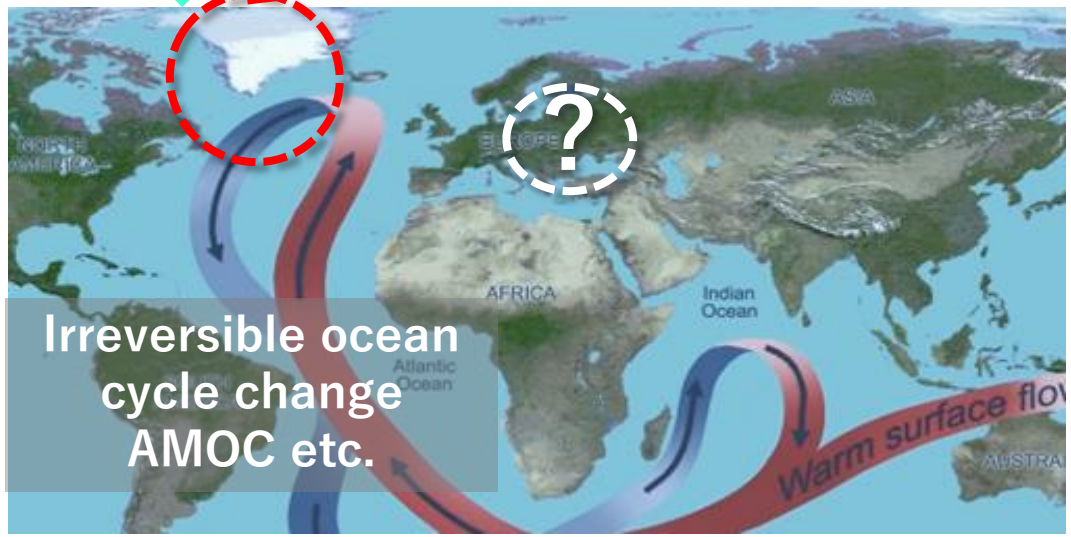
irreversible risk

⬇

SLR・AMOC stoppage

⬇

Climate？

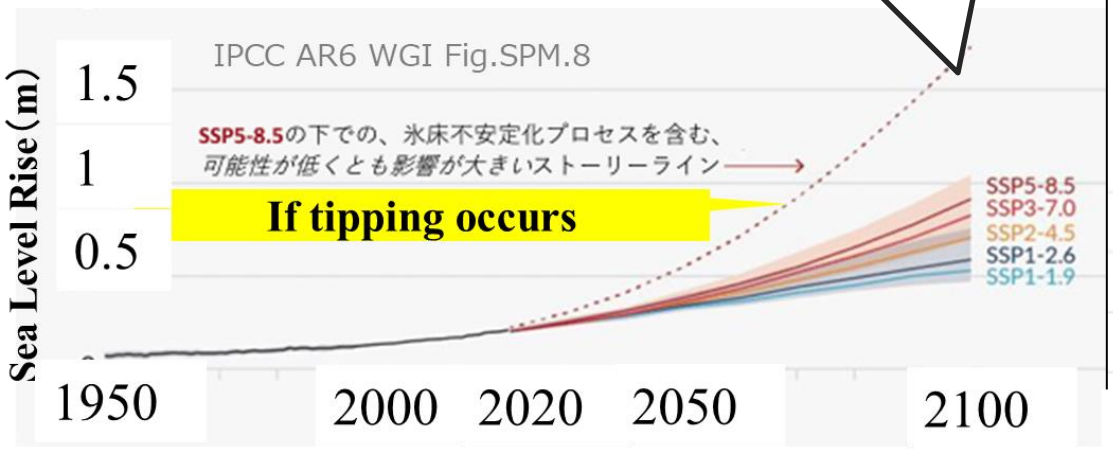


Irreversible ocean cycle change AMOC etc.

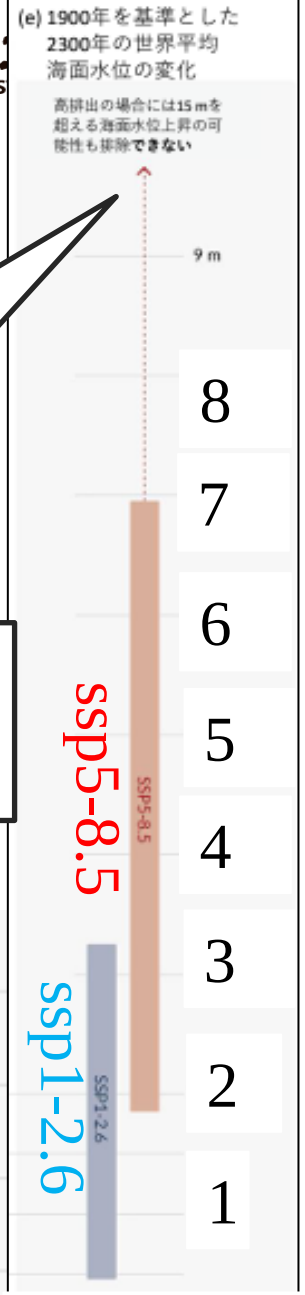
※AMOC：Atlantic Meridional Overturning Circulation

If the instability of ice sheets such as in western Antarctic continues, the upper limit could reach 15 m or more.

Up to about 1 m by 2100 under SSP-RCP climate scenarios



IPCC AR6 WGI Fig.SPM.8



SRL in 2300 (m)

What happens if tipping should occur?

Collapse of ice sheet, increased fresh water supply

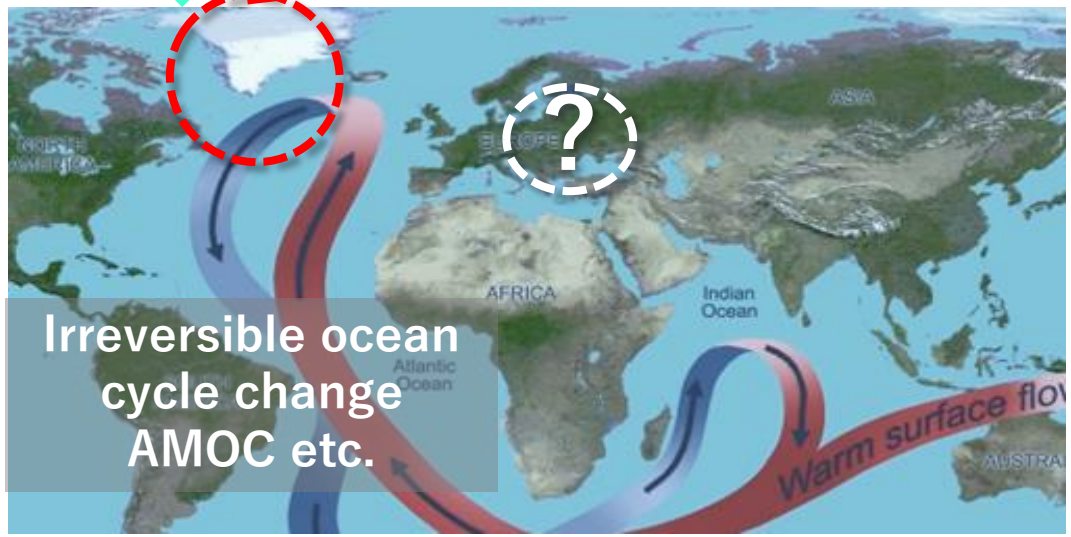
irreversible risk

⬇

SLR・AMOC stoppage

⬇

Climate？

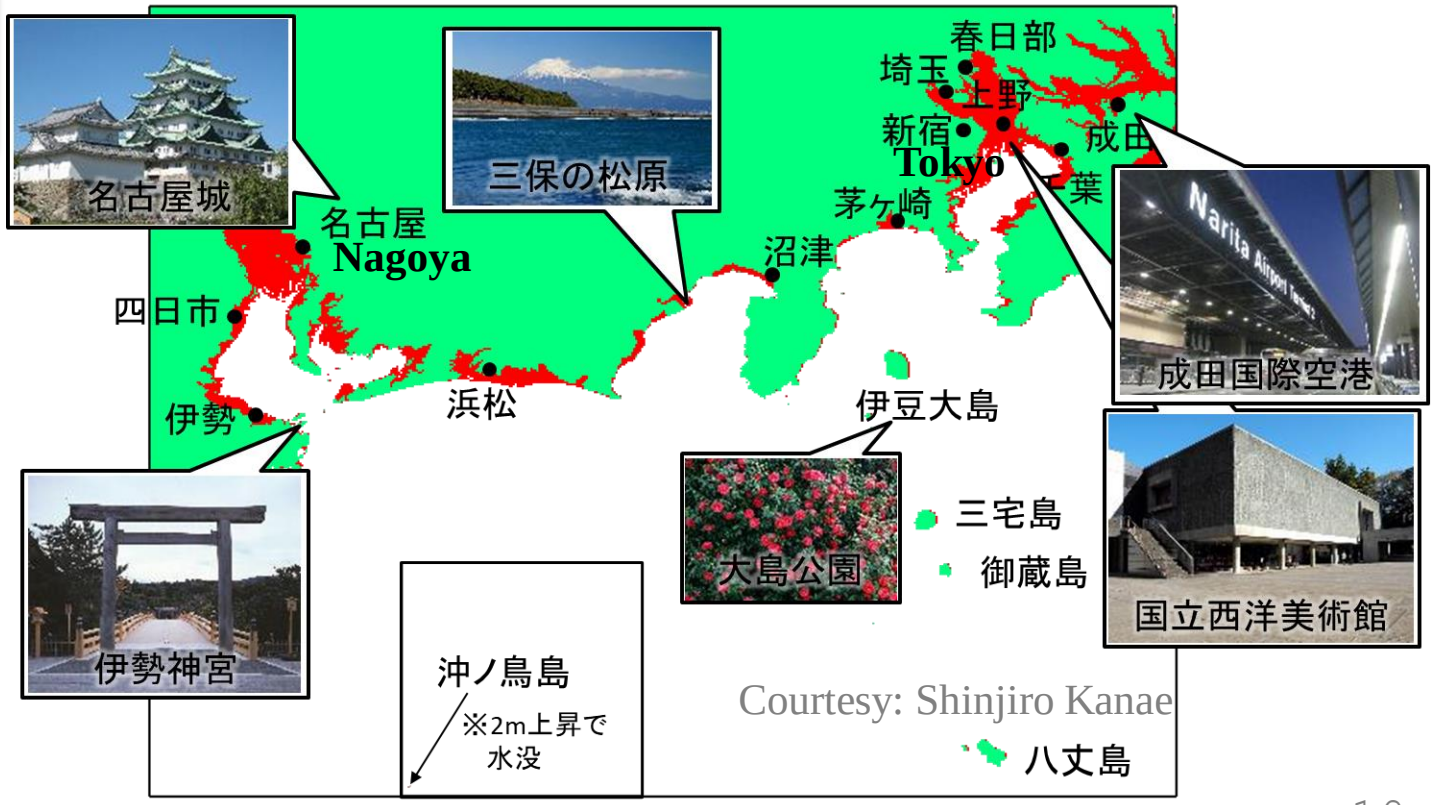


Irreversible ocean cycle change AMOC etc.

※AMOC：Atlantic Meridional Overturning Circulation

Likely loss of much of Japan's coastline
+ Combined with river flooding, typhoons, etc.?

+7m due to the collapse of the Greenland ice sheet



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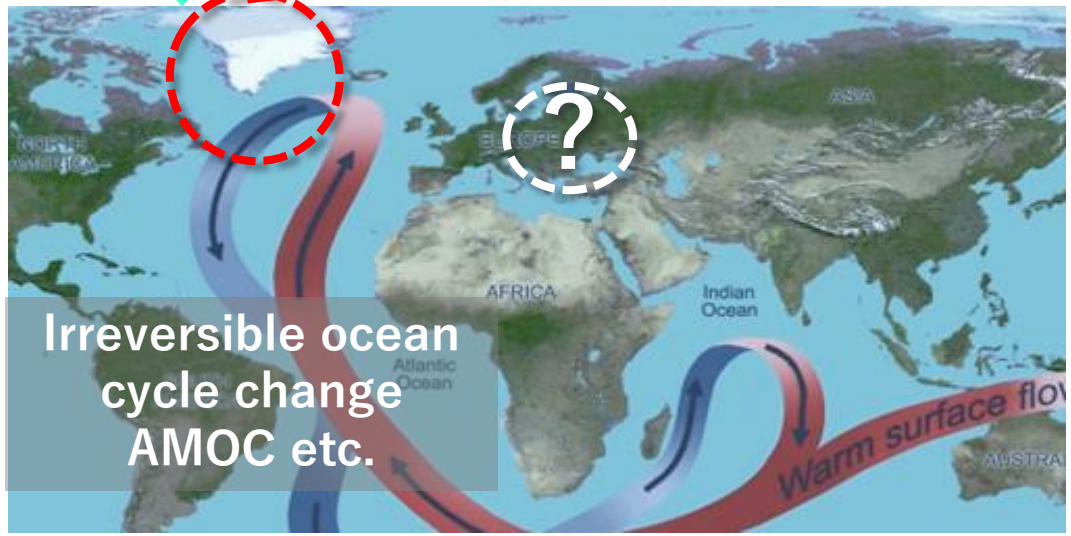


Irreversible ocean cycle change AMOC etc.

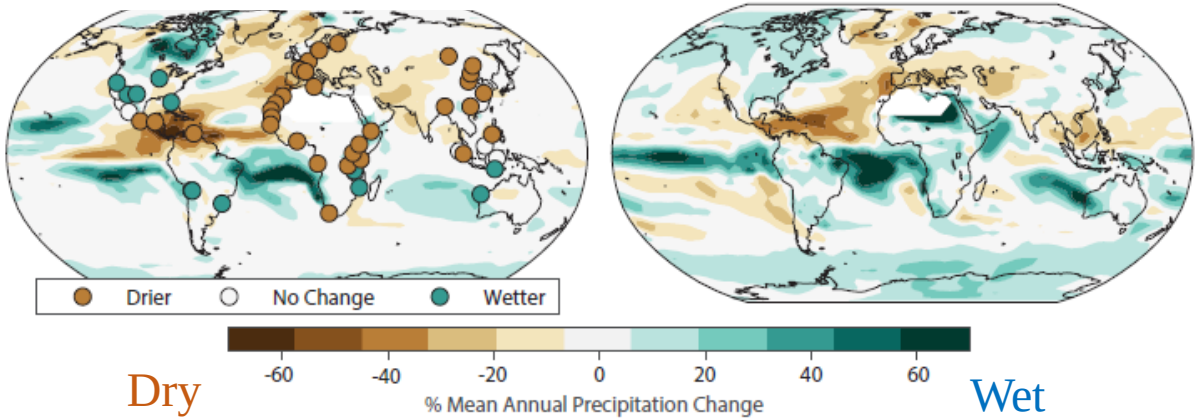
※AMOC：Atlantic Meridional Overturning Circulation

Impact on atmospheric-mediated weather hazards is unknown.

- Younger Dryas period（12,800–11,700 years ago）
  - ✓ Weakening of the African and Asian monsoons
    アフリカモンスーン・アジアモンスーンの弱化
  - ✓ Strengthening of Southern Hemisphere monsoon system
    南半球のモンスーンシステムの強化
  - ✓ Drying of meso-America and Europe
    メソ-アメリカとヨーロッパの乾燥化
  - ✓ Wetting of the mid-latitude North America
    北米の中緯度の湿潤化

Younger Dryas Event

AMOC weakening, 2×CO_2



Dry 乾燥化

IPCC AR6 WGI Fig.8.27

Wet 湿潤化

Summary

- There is great synergy between mitigation and adaptation measures to improve vulnerability to fluvial flooding, water quality and water resources.
- For SDG targets on water, synergies from climate policies significantly outweigh trade-offs, and should be actively pursued with consideration regarding areas/items of trade-off concern.
- Promoting BECCS relying on too much water use may prevent a reduction in the disparity in the rate of irrigation adoption by small farmers.
- The countries with the largest synergies and trade-offs are mainly developing countries in Asia and Africa, suggesting the importance of international support for adaptation measures.
- If our climate goes beyond a tipping point, this might lead to catastrophic changes.
  - ✓ Disastrous sea level rises ranging from several meters to as much as ten meters.
  - ✓ Slowing or cessation of the Atlantic Meridional Ocean Circulation (AMOC) due to the freshwater supply from melting ice sheets may impact on climate.
- A rapid transition to a low-carbon society is imperative in reducing the likelihood of such catastrophic tipping element.