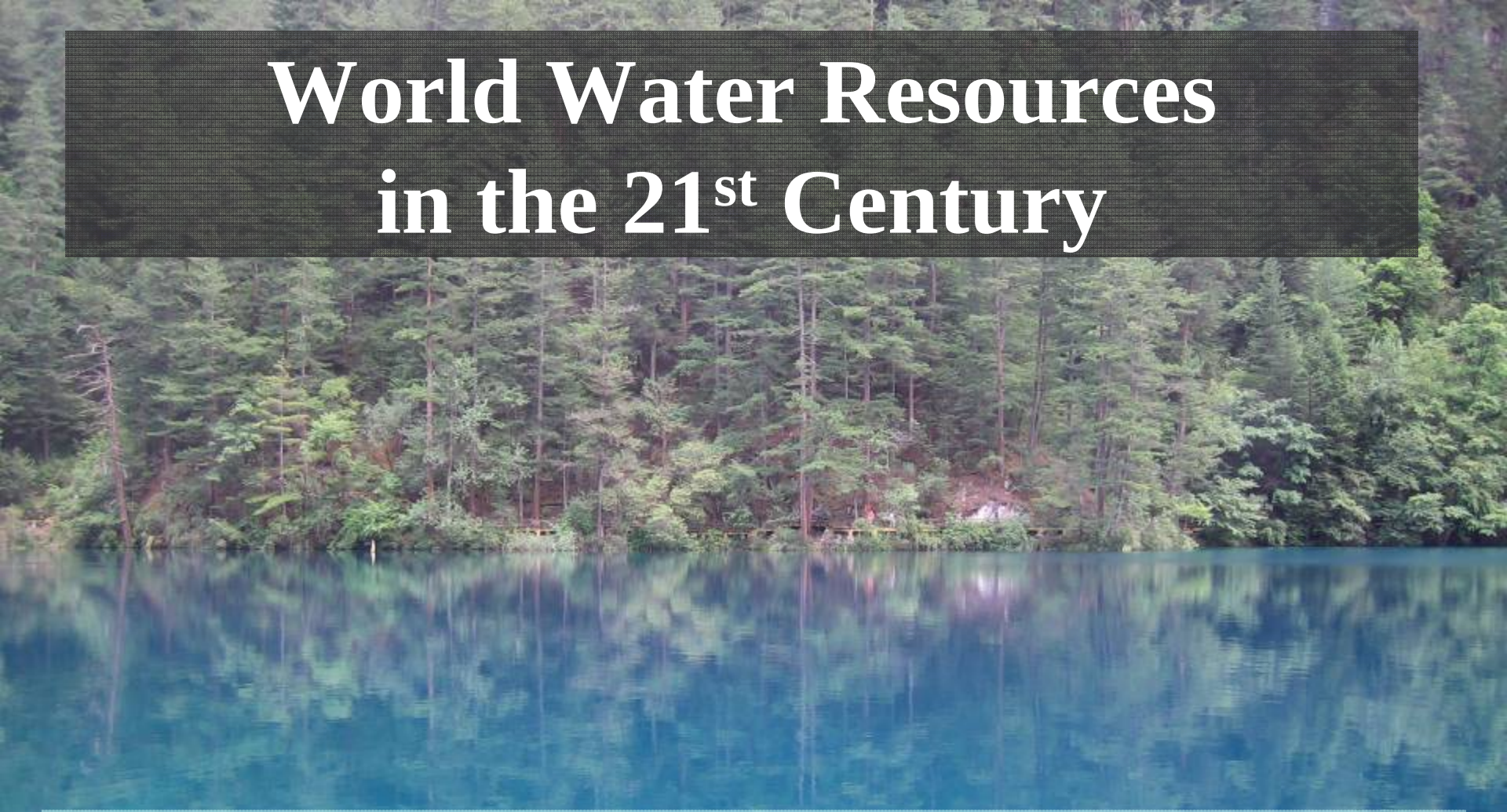
World Water Resources in the 21st Century



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Global Innovation Ecosystem (GIES) 2008 Workshop
National Center of Sciences Building, Tokyo, March 14th, 2008

World Water Issues

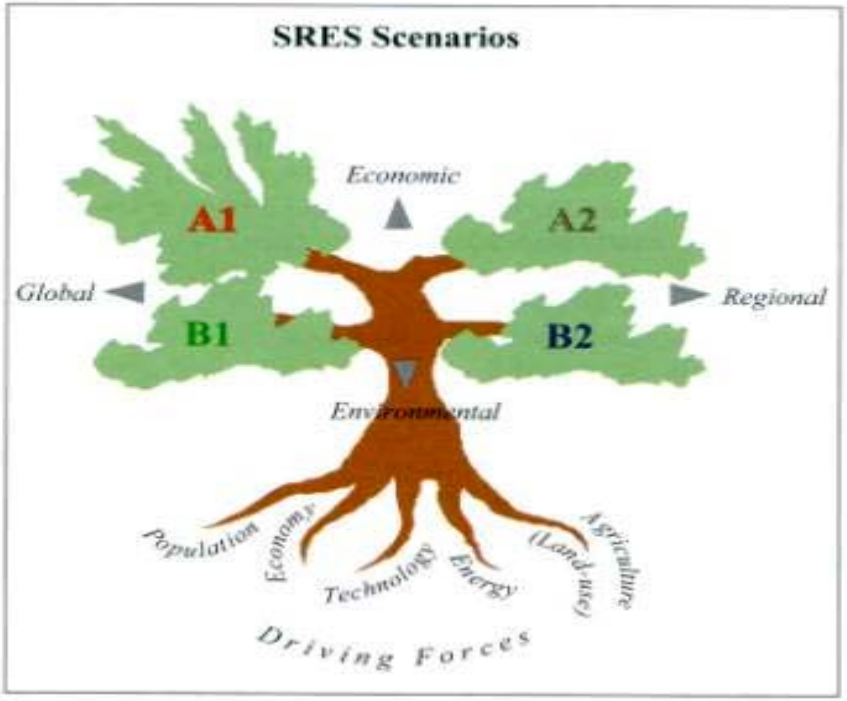
- **Indispensable water for lives**
  - **One in five of the world population does not have access to safe and affordable drinking water (20L/d/c within 1km).**
    - **Each year 3-4 million people die because of waterborne diseases**
- **Profitable water for agriculture and industry**
  - **Total withdrawals 3,800km^3(1995)➔4,300-5,200km^3(2025)**
- **Comfortable water for human being and ecosystems**
- **Climate Change and Urbanization ➔water hazard risks**
- **International conflicts because of water issues?**

Future Projection through the 21st Century

Changes considered include:

- **Water demand for domestic, industrial, and irrigation sectors.**
  - **Population (SRES)**
    - **Urban and rural areas separated**
  - **GDP (SRES)**
  - **Improvement of reuse (SRES)**
- **Climate change (SRES)**

IPCC SRES Scenarios



A : Economic growth oriented

B : Environmentally oriented

1 : Globalization

2 : Regionalization

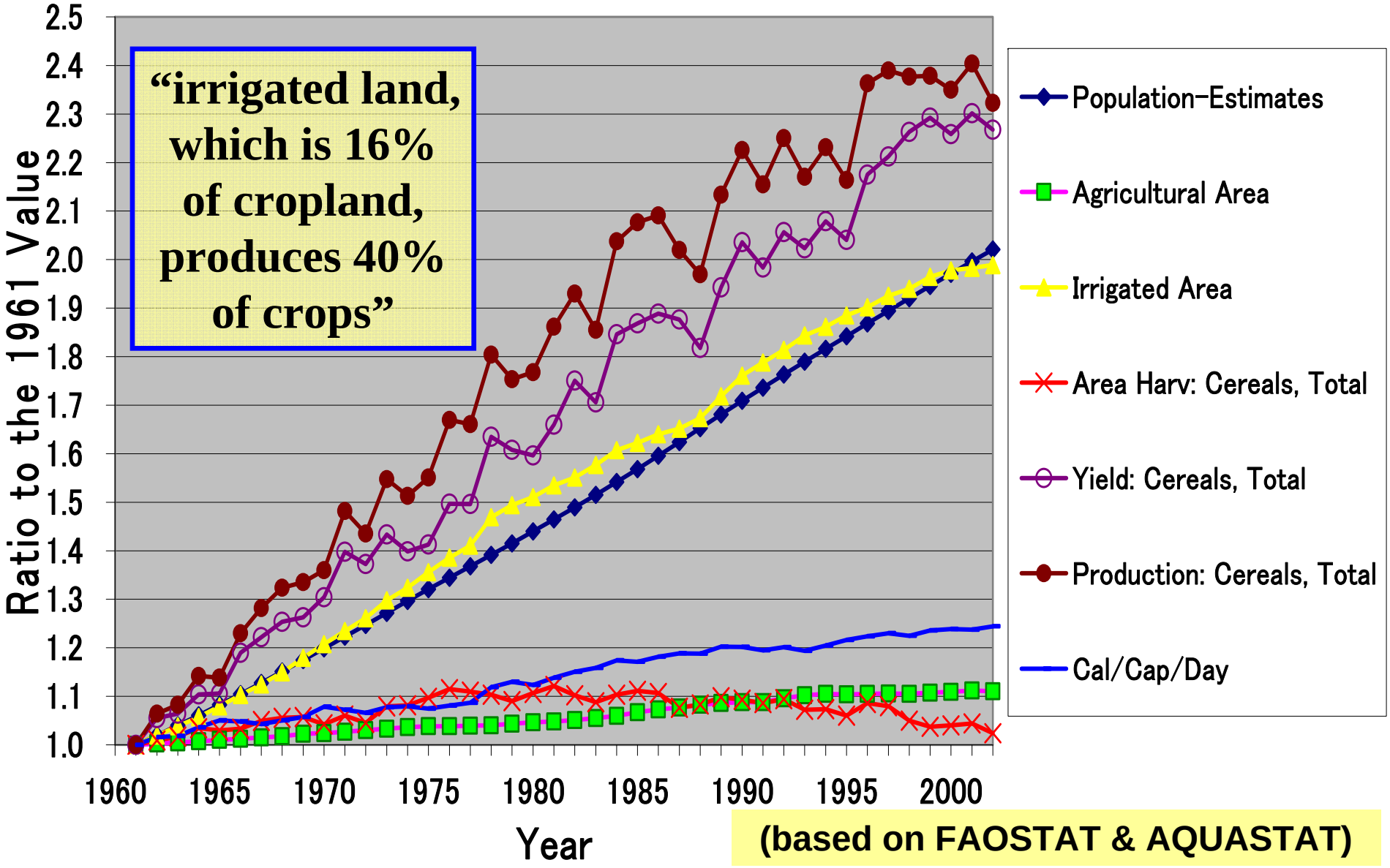
A1 : Fast development in economy and population. Technological transfer as well. A1b will use use various energy from multiple sources developed.

A2 : Regions are isolated. Slow technological transfer and culture. Population growth will be extremely high.

B1 : Globalization and similar population growth as A1, but environmentally conscious and technological transfer and development of new technology and new energy are fast. Sustainability in economy, society, and environment are enhanced globally.

B2 : Less population than A2 but more than A1 and B1. Sustainability is focused but solved regionally.

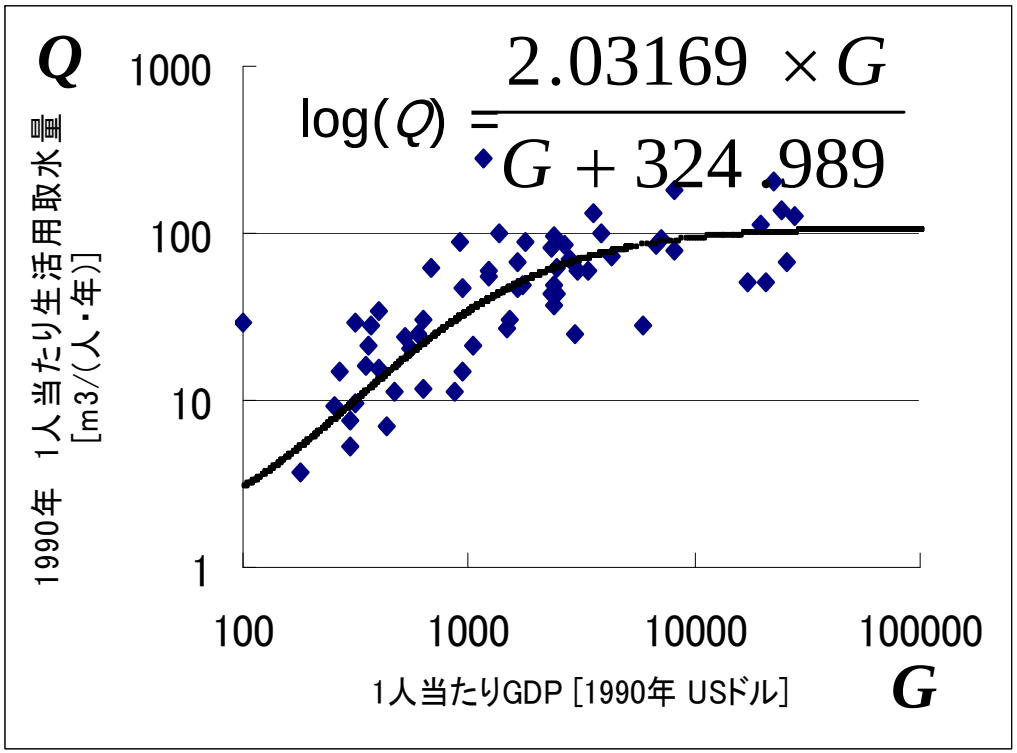
World Food Production and Supply



(based on FAOSTAT & AQUASTAT)

GDP and Domestic Water Use

GDP/capita and domestic water use



Q: Domestic Water Use [m3 / capita/year]
G: GDP per person [US$ equivalent of year 1990]

Assumptions:

1. Domestic water use in developing countries will increase associated with the increase of GDP.
2. Life style in domestic water use is calibrated by simple manner for countries with statistics of the current domestic water use.

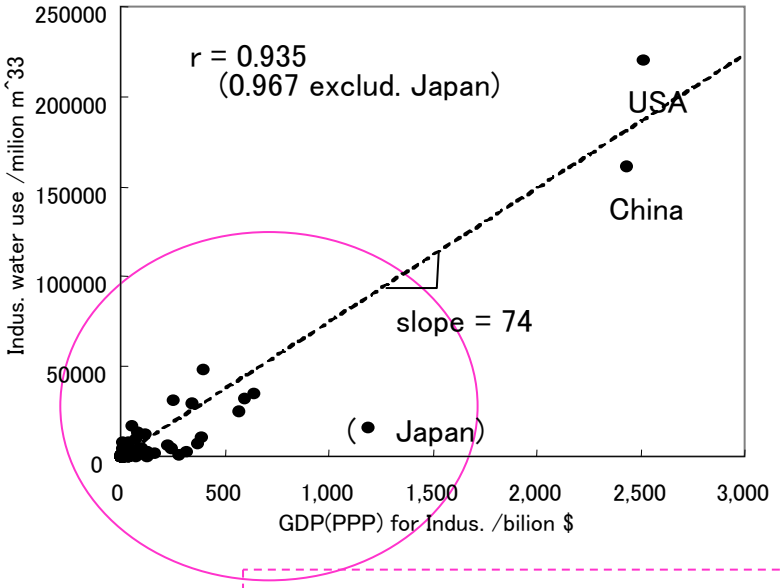
- Future Domestic Water Use= Future Estimate +D

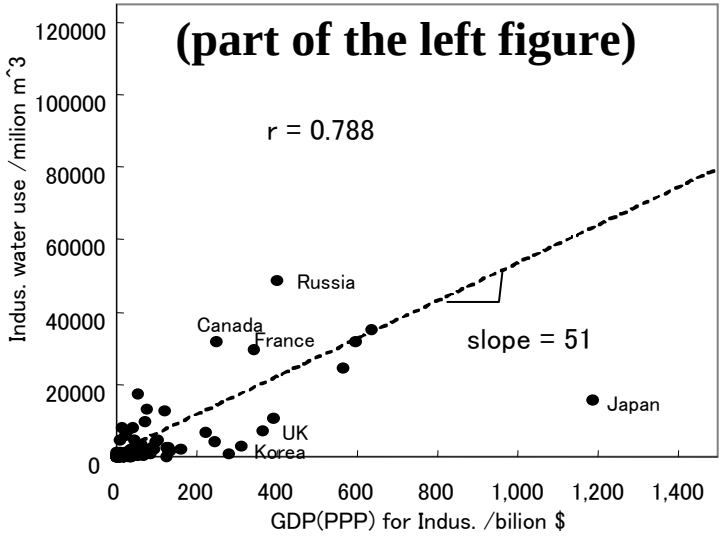
where D is the bias error,
D=Statistics in 1900 – Estimate for 1990

*** Future GDP under SRES scenario was downscaled from GDP projection in 4 region in the world into each country by CIESIN.**

GDP and Industrial Withdrawals

Total water withdrawal and GDP for industry in each country are proportional.





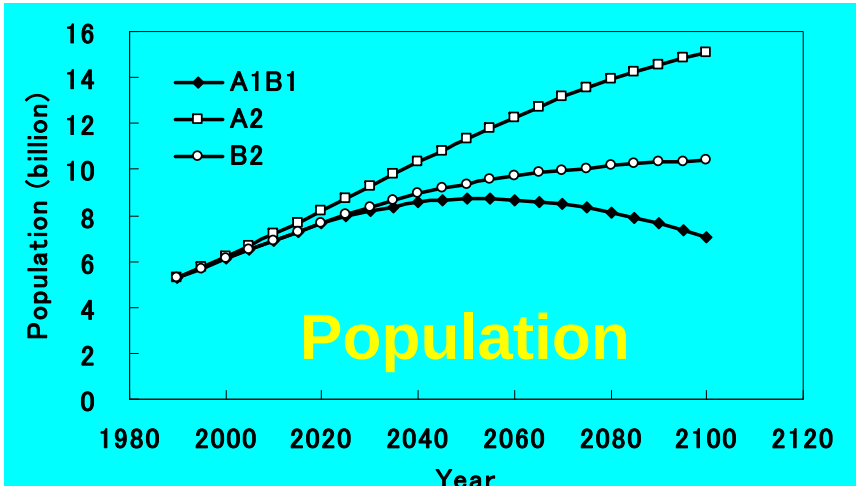
Japan is an exception with high water use efficiency.

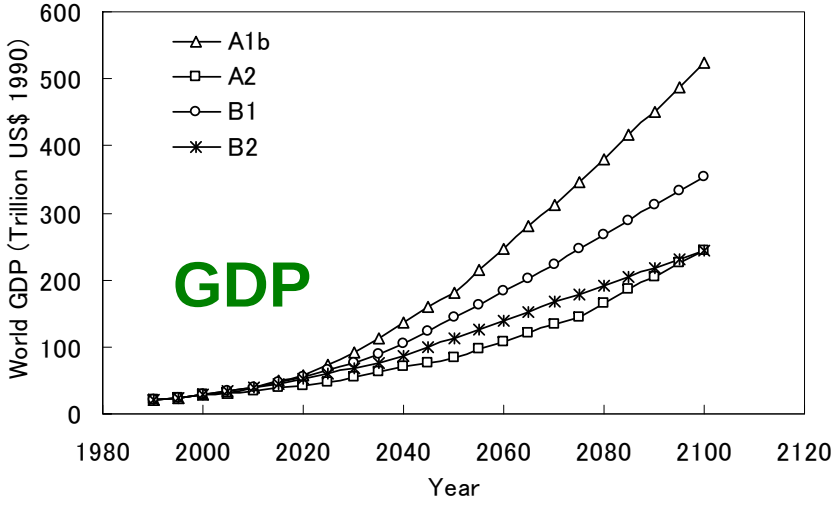
Future Projection

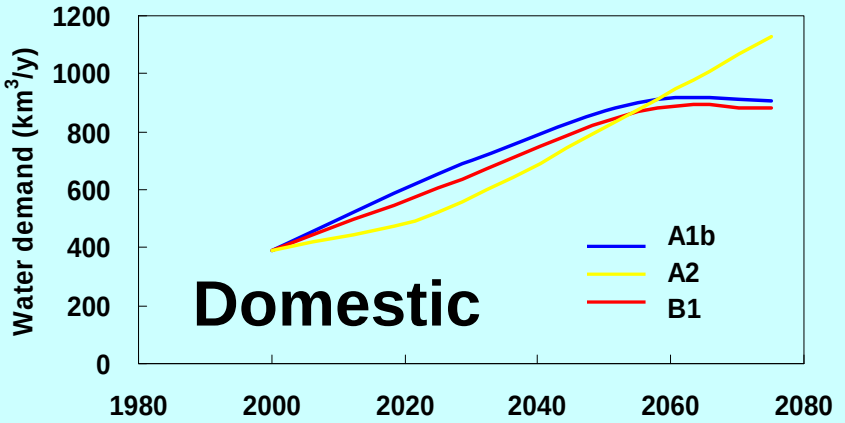
Future IW＝Current IW ＊GDP Growth for Industry
＊Improvement of water use efficiency

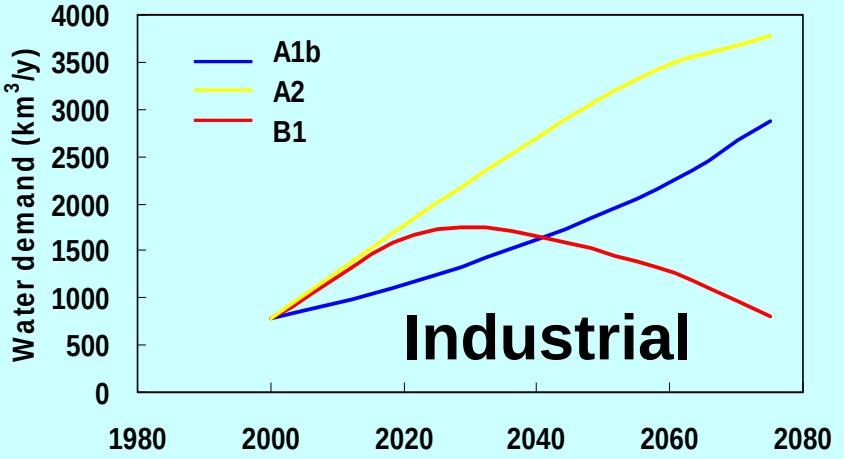
Future Projection

- SRES based
  - Population (urban & rural), GDP, efficiency
  - Climate change
- Global 0.5 degree grid distribution based

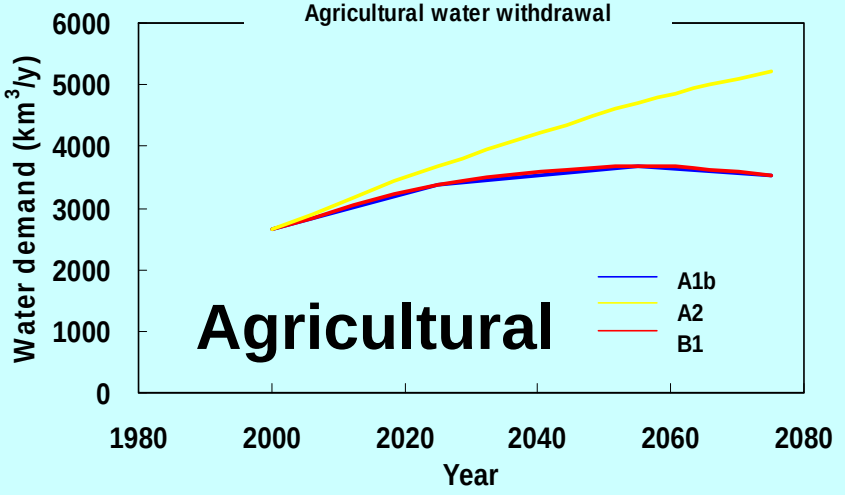




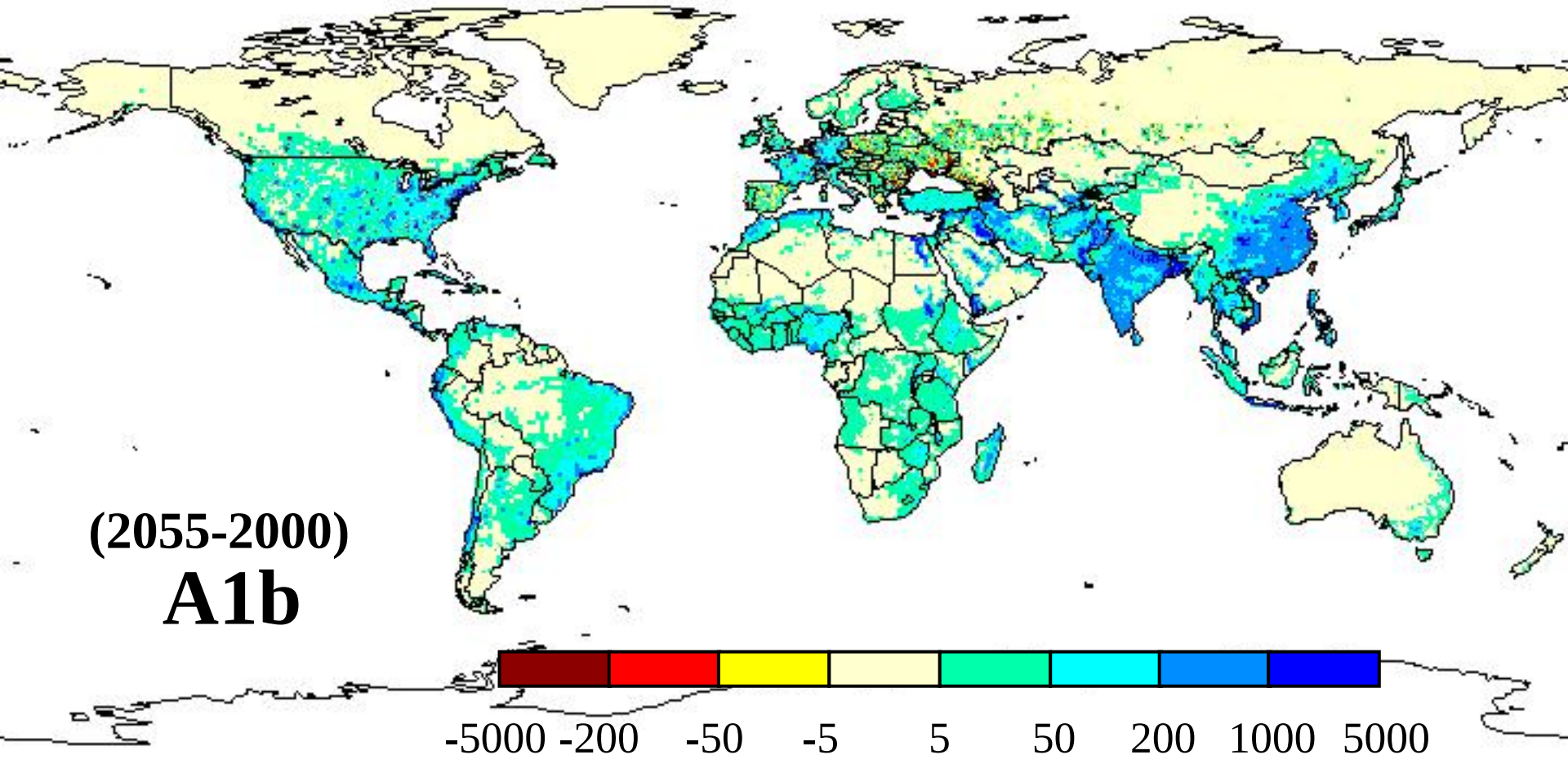




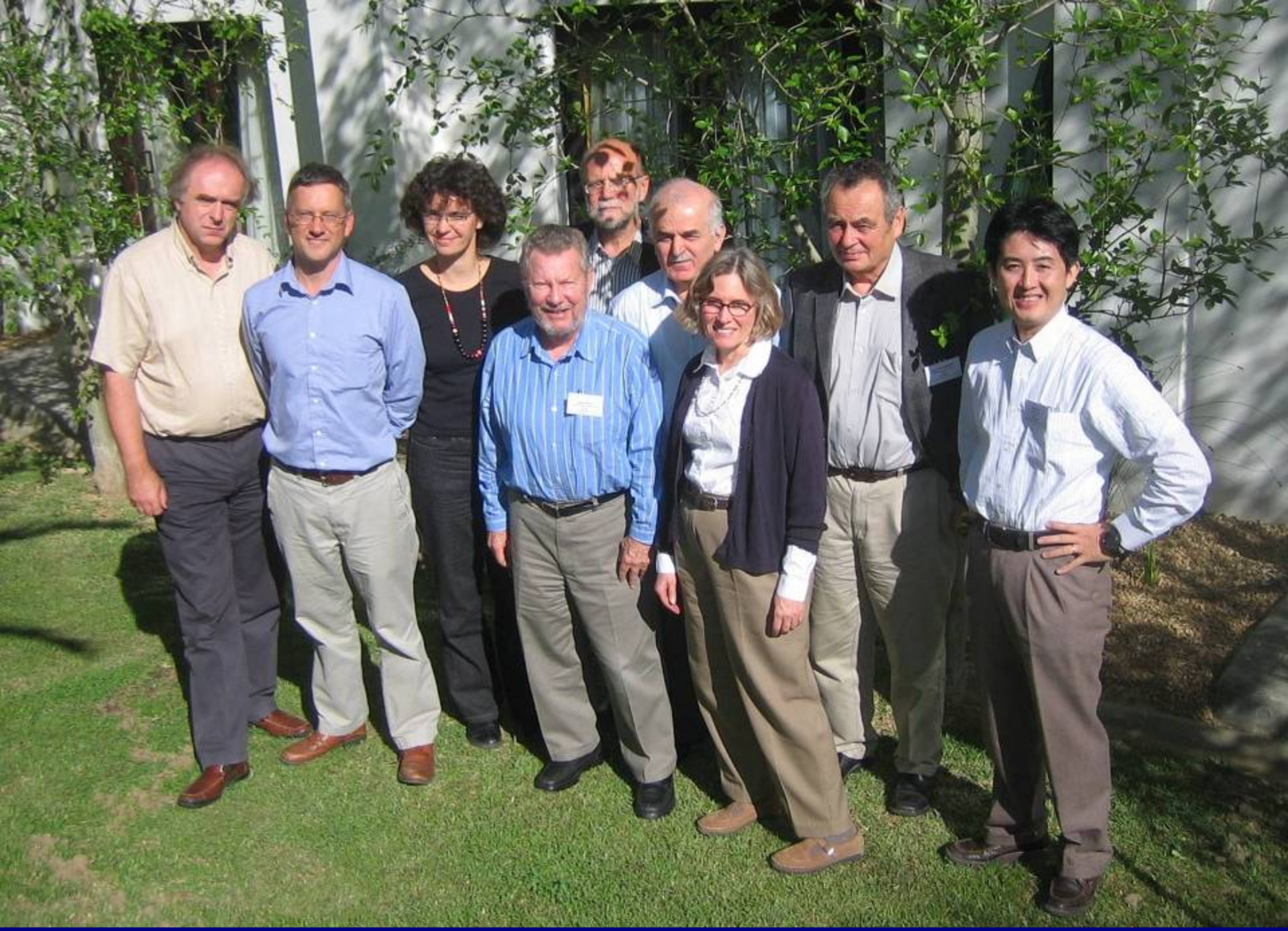
Agricultural water withdrawal



Total Water Withdrawal ($10^6 m^3/y$) in 2050 (difference to Year 2000)



(Shen, et. al, 2008, HSJ)

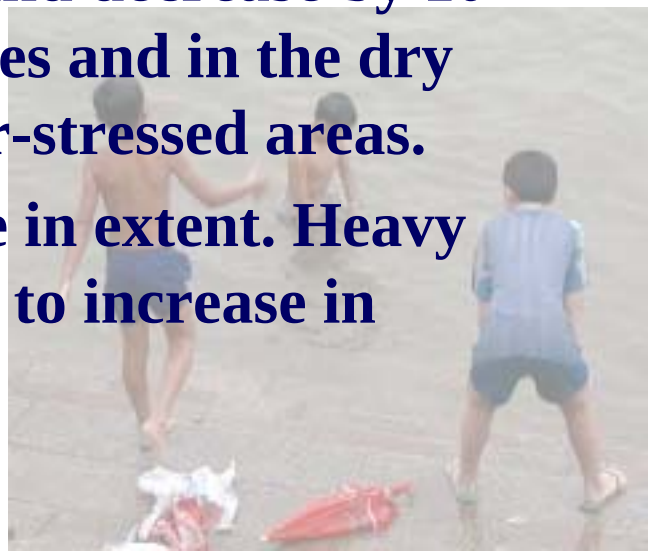


（Lead Authors for the 4th Assessment Report of the IPCC, WG II, Chapter 3 “Freshwater resources and their management”）

Impacts of climate change on freshwater fesources

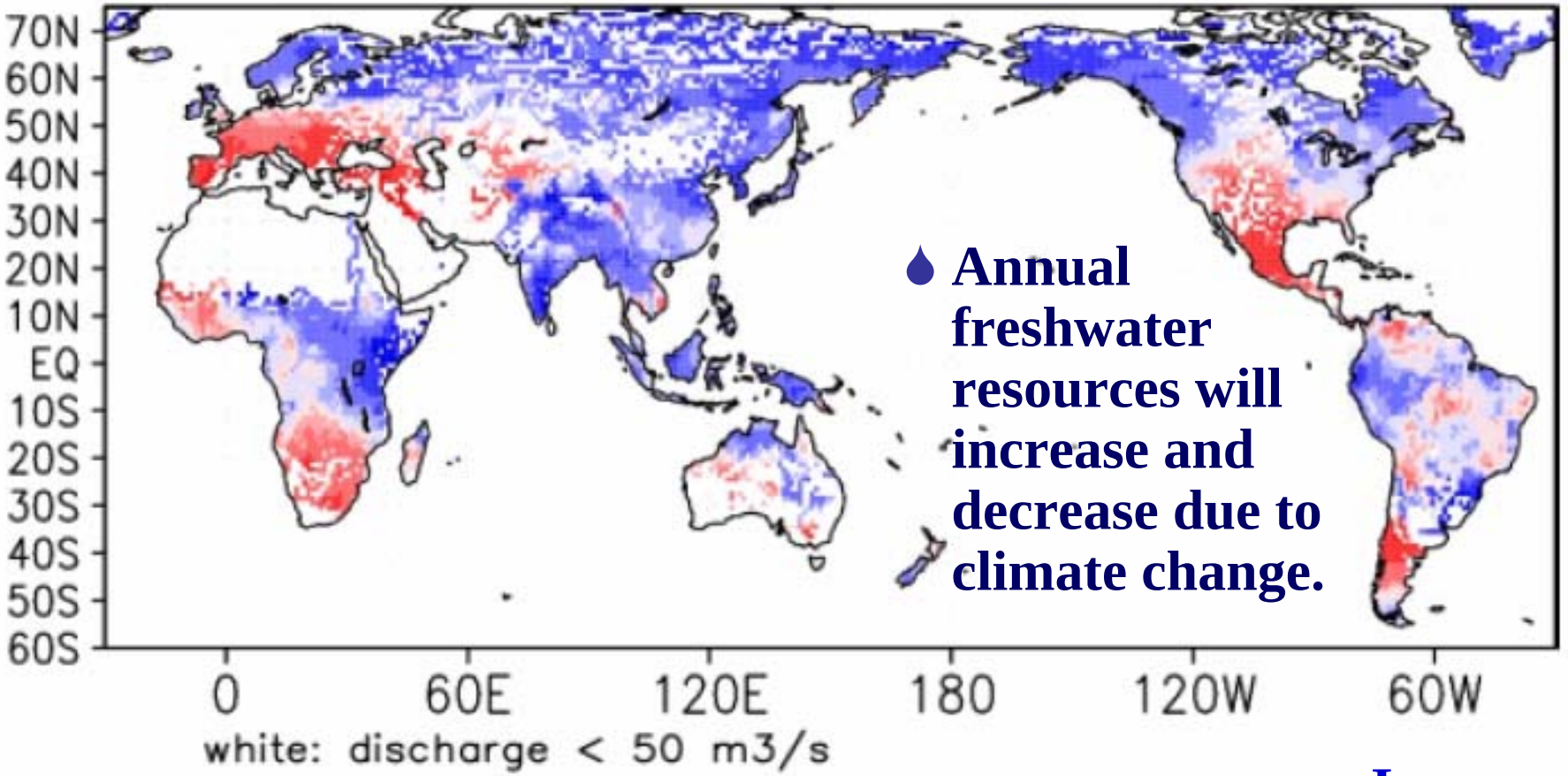
- In the course of the century, water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by melt water from major mountain ranges, where more than one-sixth of the world population currently lives.
- By mid-century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water-stressed areas.
- Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk.

（IPCC AR4, WGII, SPM, 2007）



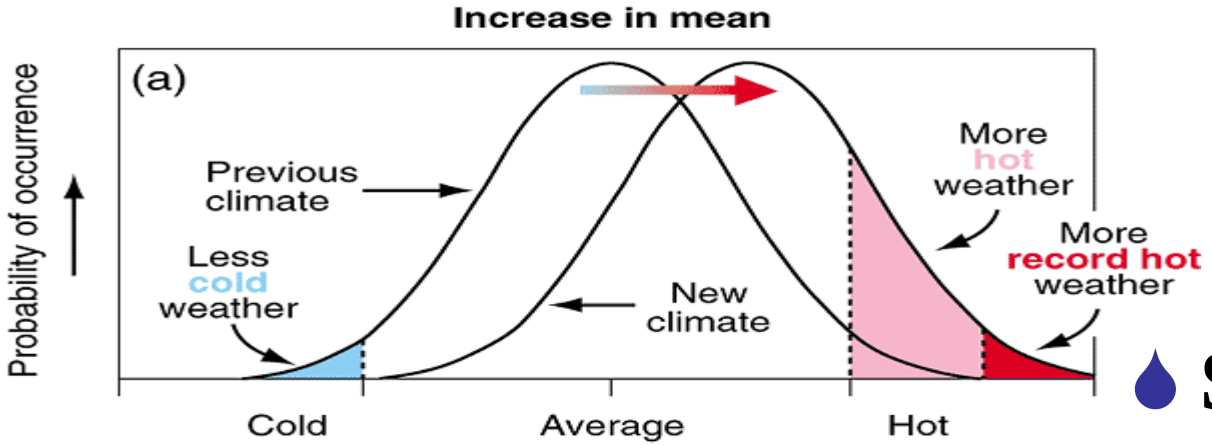
Changes in Annual River Discharge

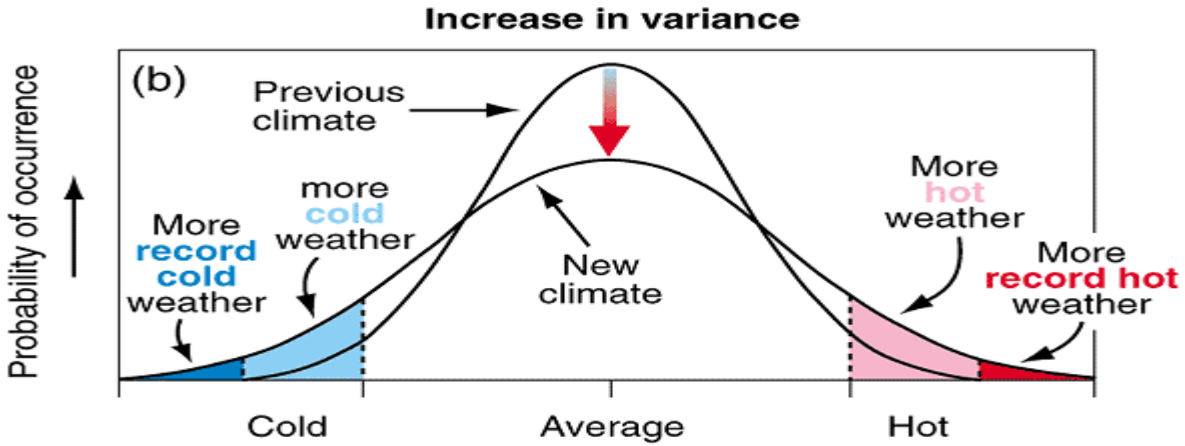
---Ensemble Mean of 15 GCM results for IPCC AR4 ---

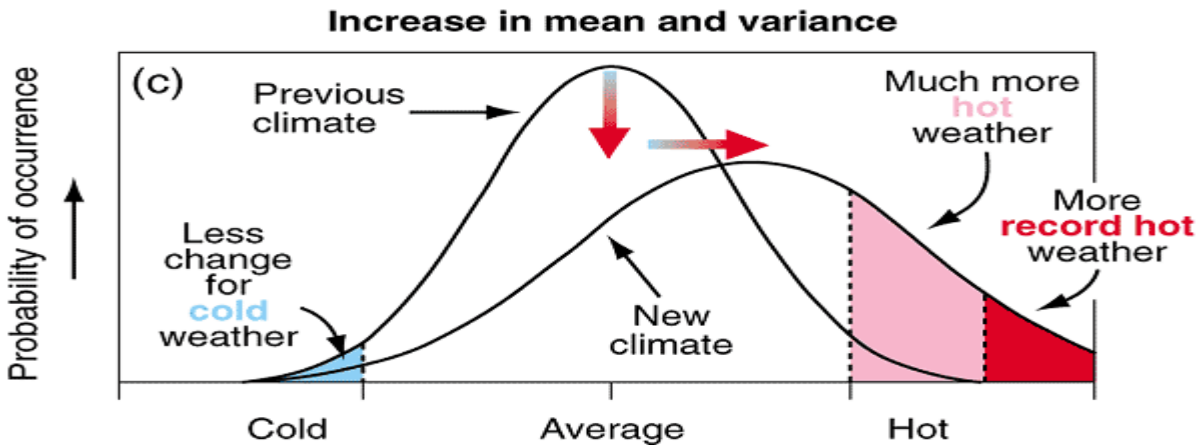


(A1B)

(Nohara, et. al, 2006, *J Hydrometeor.*)







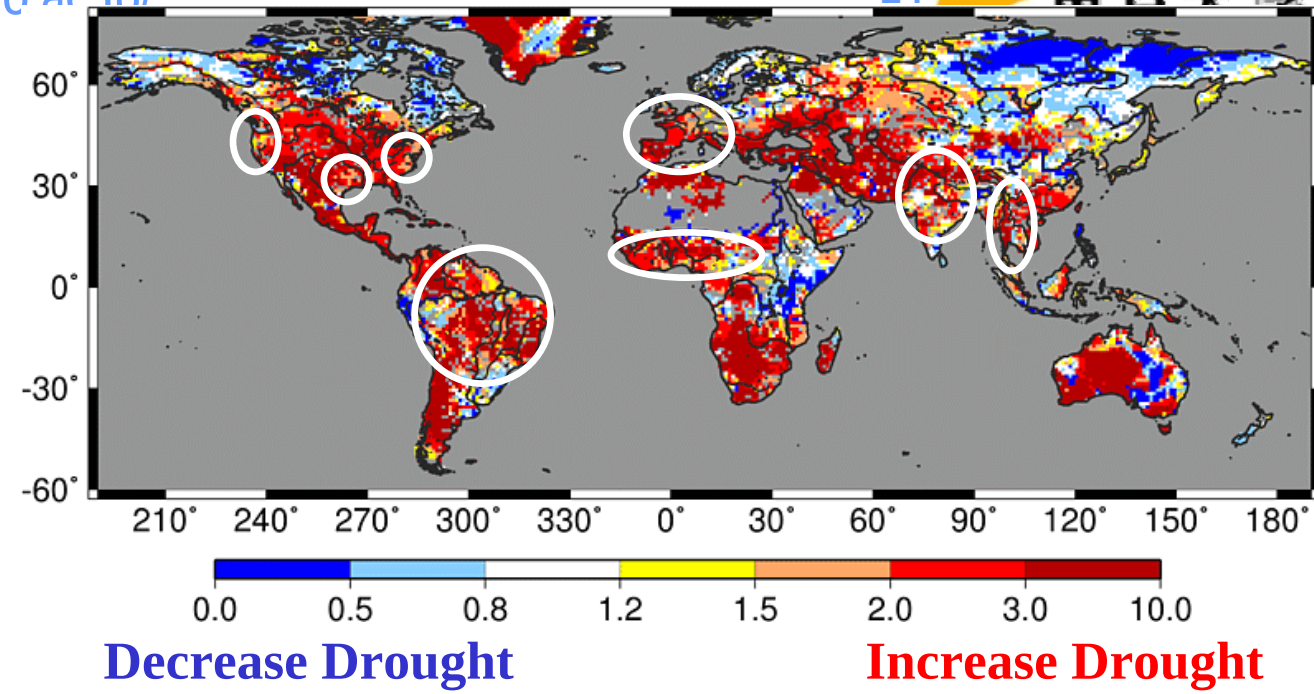
- **Signals of CC could be detected through the change of the frequency of extreme events?**

(IPCC TAR, 2001)

Change in Drought Frequency

End of 21st century compared with 20th century

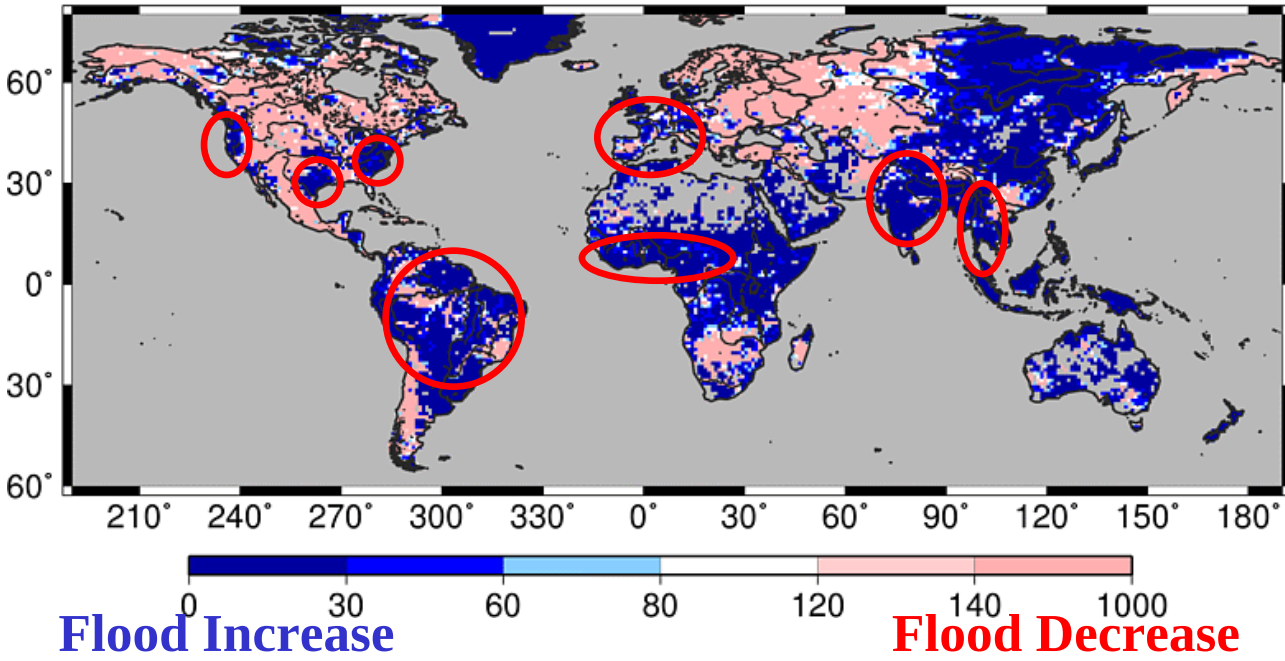
Drought: daily river discharge is below threshold of 10% percentile



Change in Flood Frequency

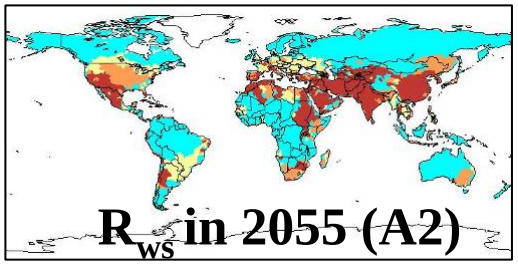
End of 21st century compared with 20th century

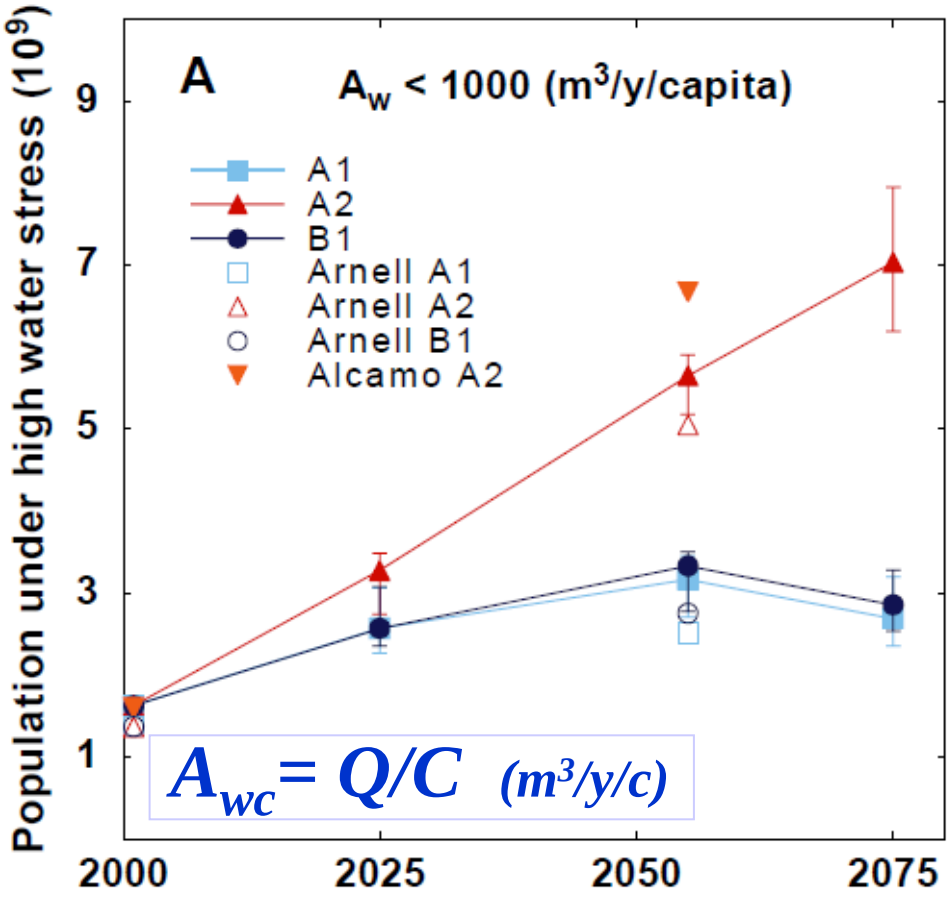
Frequency in the 21st century of 100-year flood in the 20th century

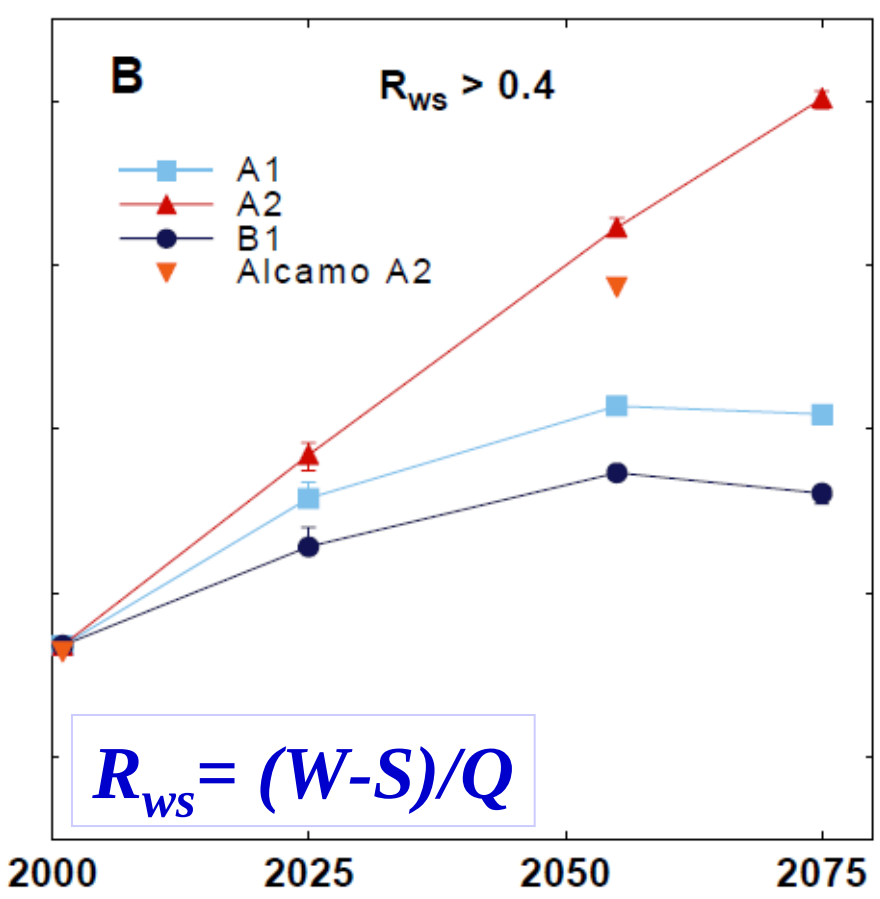


Hirabayashi et al., (in revision)
Based on CCSR-NIES AOGCM

Number of people under serious water stress





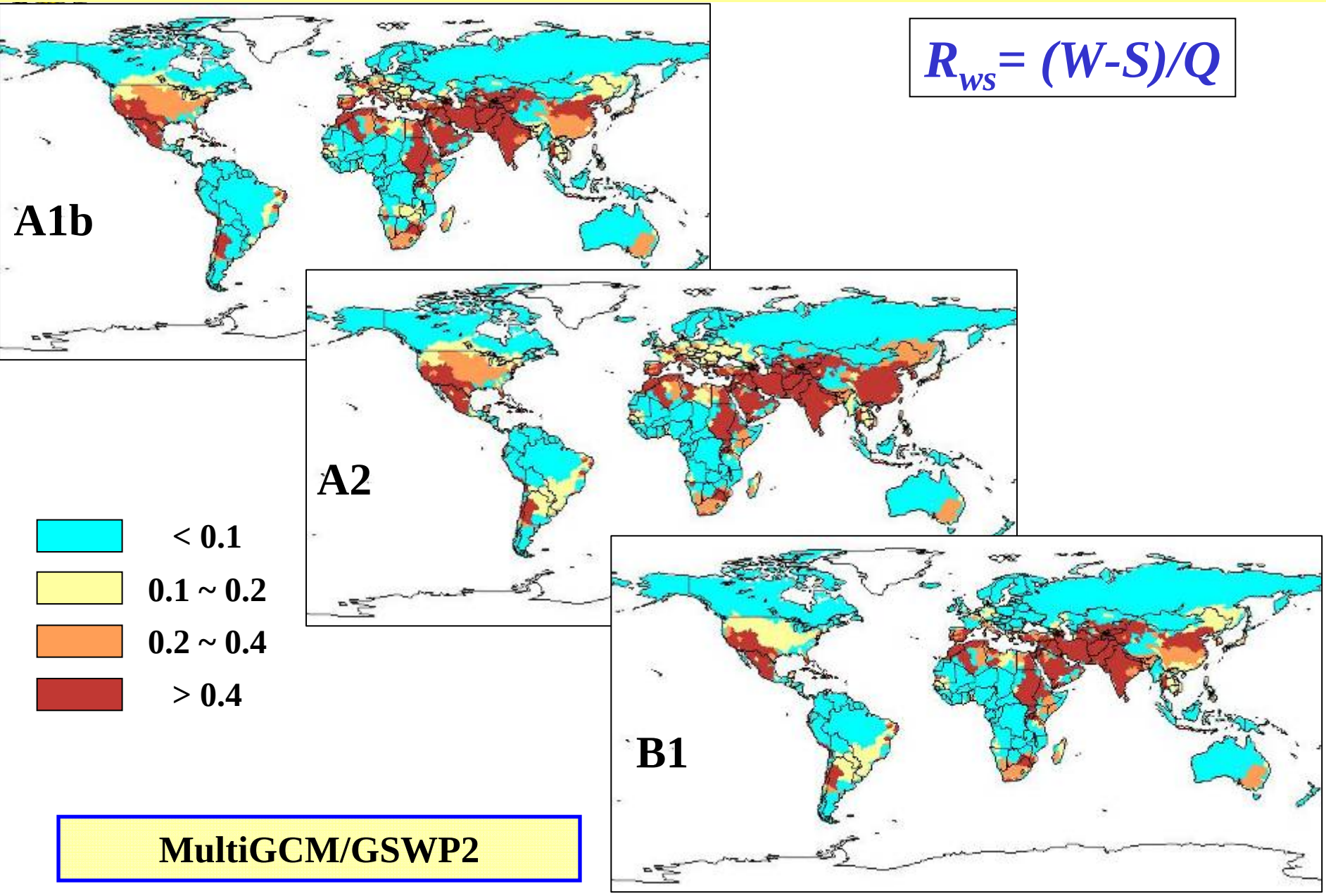


Q: How can we realize B1 society?

(Oki and Kanae, *Science*, 2006)

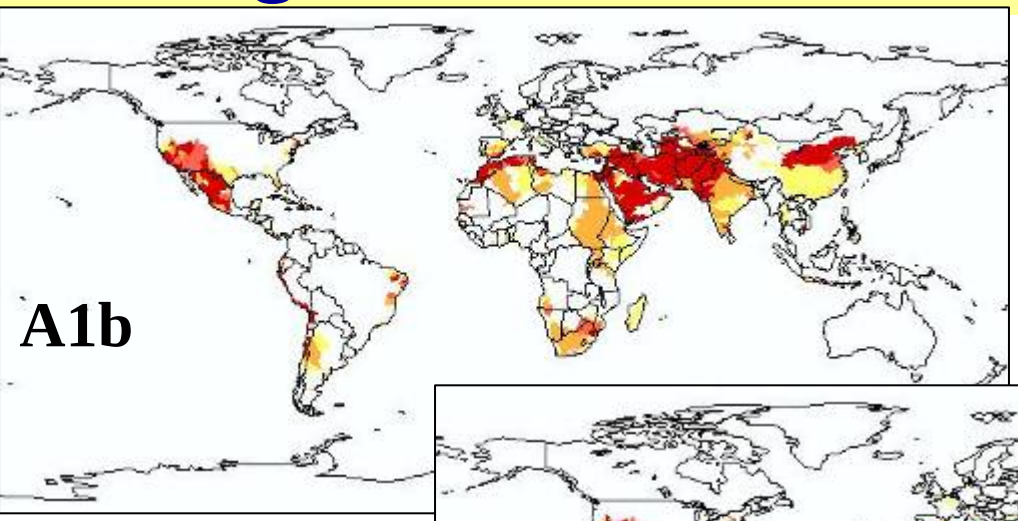
Water stress index in 2050

$$R_{ws} = (W-S)/Q$$

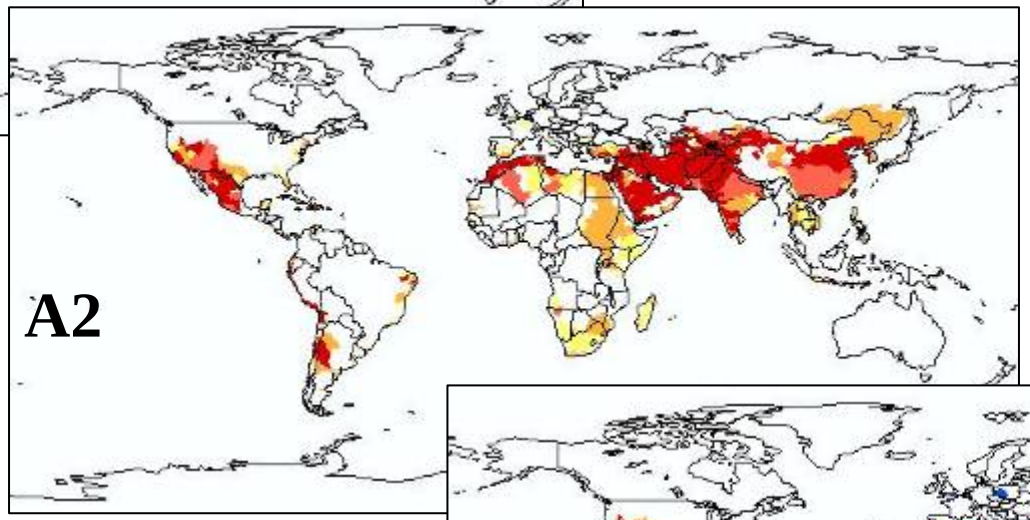


MultiGCM/GSWP2

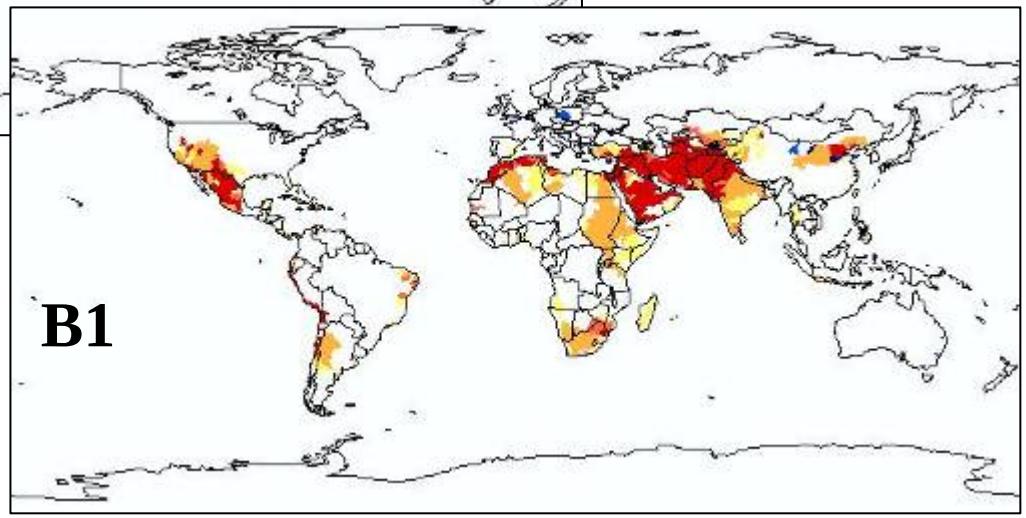
Change in water stress index for 2050 (difference)



2055-2000

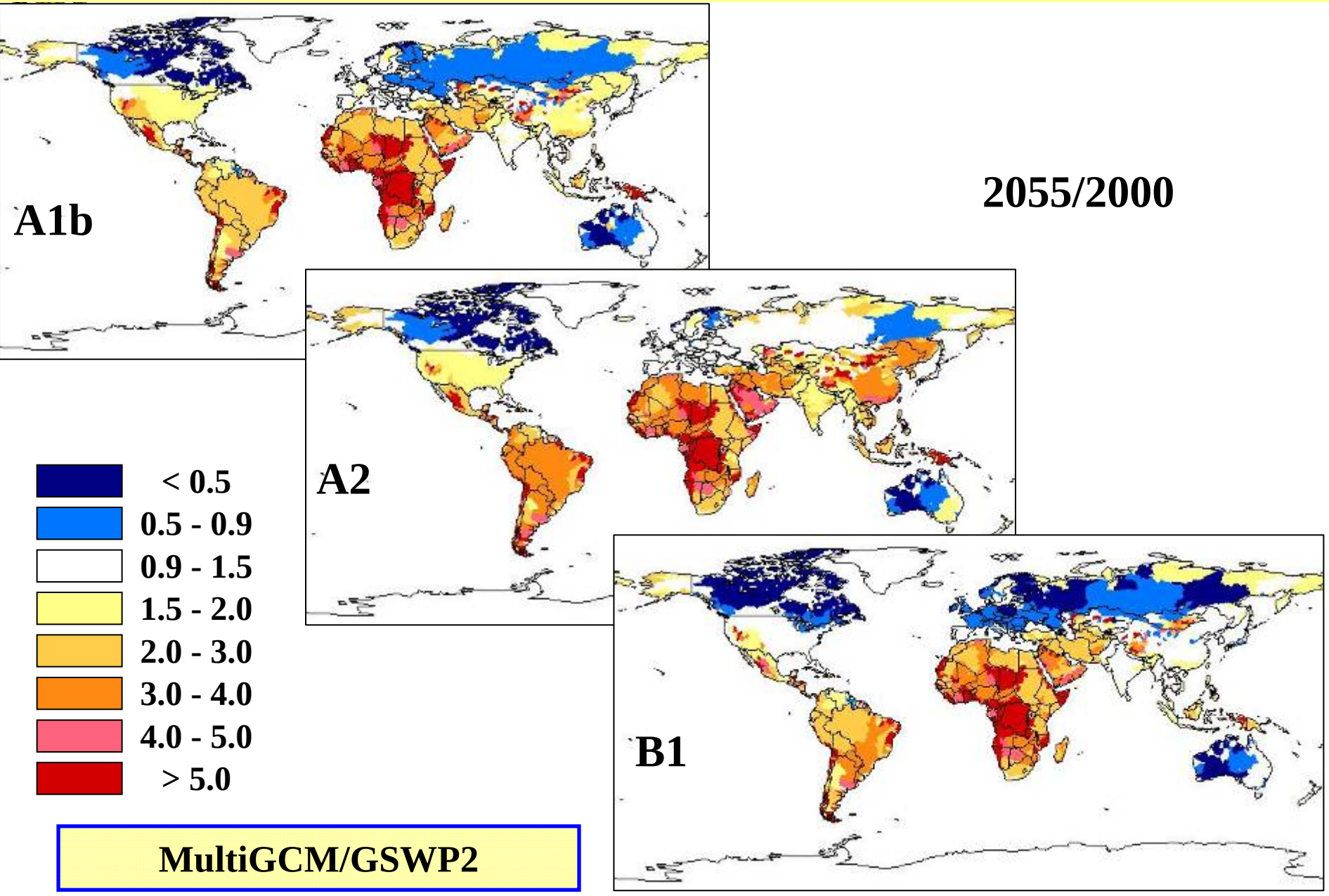


< -0.2
-0.2 ~ -0.1
-0.1 ~ 0.1
0.1 ~ 0.2
0.2 ~ 0.4
0.4 ~ 0.6
> 0.6



MultiGCM/GSWP2

Change in water stress index for 2050 (ratio)



Impact of human activities on freshwater resources and their management, with climate change being only one of multiple pressures

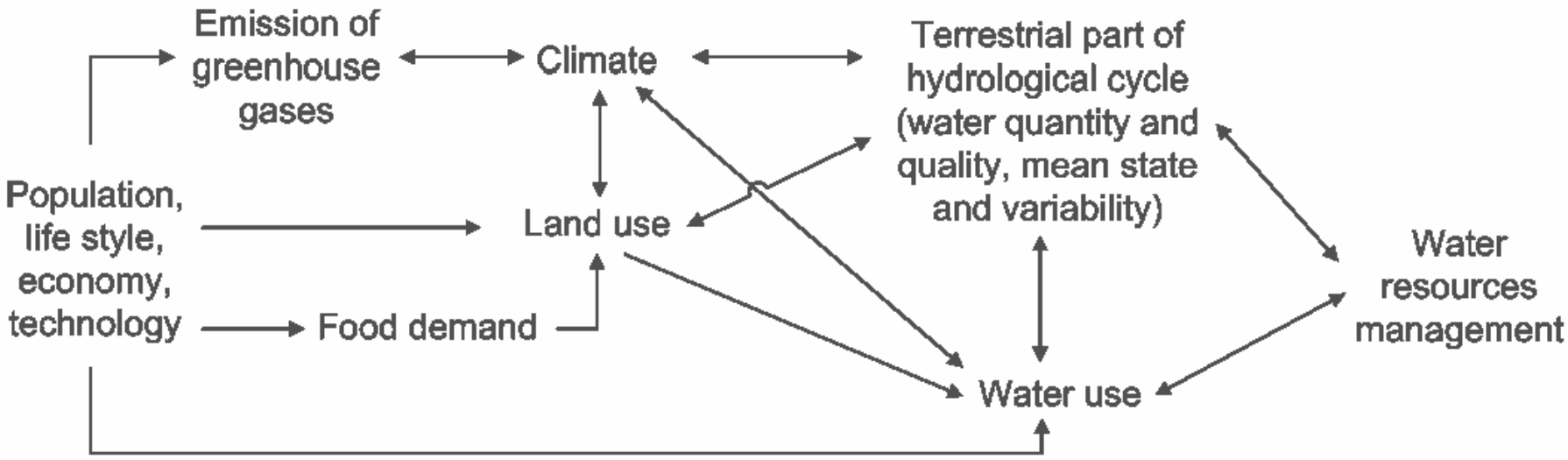


Figure 3.1: Impact of human activities on freshwater resources and their management, with climate change being only one of multiple pressures (modified after Oki (2005)).

(IPCC AR4, WGII, Chapter 3, "Freshwater Resources and their Management", 2006)

Adaptation Options

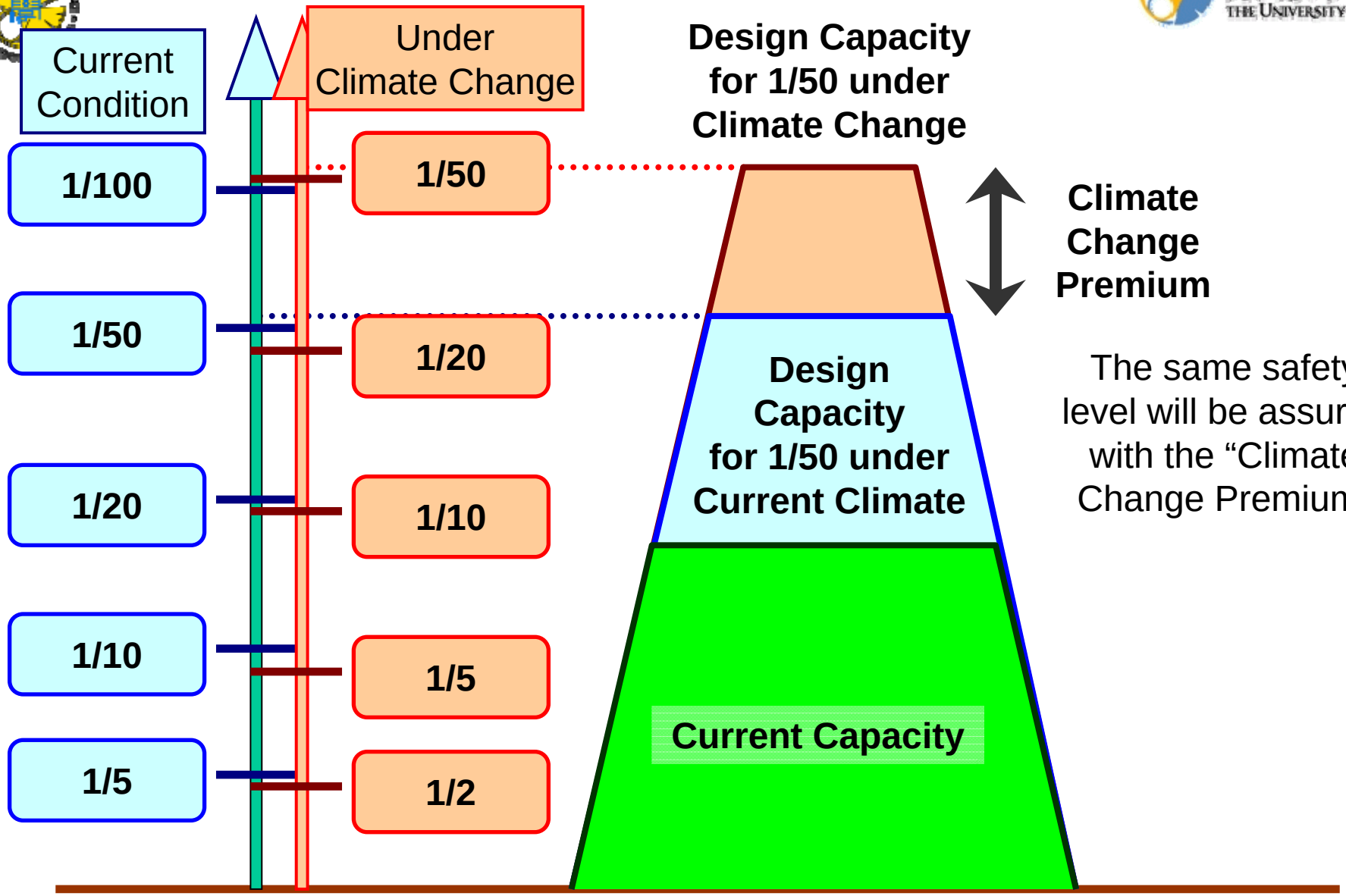
- **Supply-side**
  - **Prospecting and extraction of groundwater**
  - **Increasing storage capacity by building reservoirs and dams**
  - **Desalination of sea water**
  - **Expansion of rain-water storage**
  - **Removal of invasive non-native vegetation from riparian areas**
  - **Water transfer**

(IPCC AR4, WGII Ch3, 2007)

Adaptation Options

- **Demand-side**
  - **Improvement of water-use efficiency by recycling water**
  - **Reduction in water demand for irrigation by changing the cropping calendar, crop mix, irrigation method, and area planted**
  - **Reduction in water demand for irrigation by importing agricultural products, i.e., virtual water**
  - **Promotion of indigenous practices for sustainable water use**
  - **Expanded use of water markets to reallocate water to highly valued uses**
  - **Expanded use of economic incentives including metering and pricing to encourage water conservation**

(IPCC AR4, WGII Ch3, 2007)



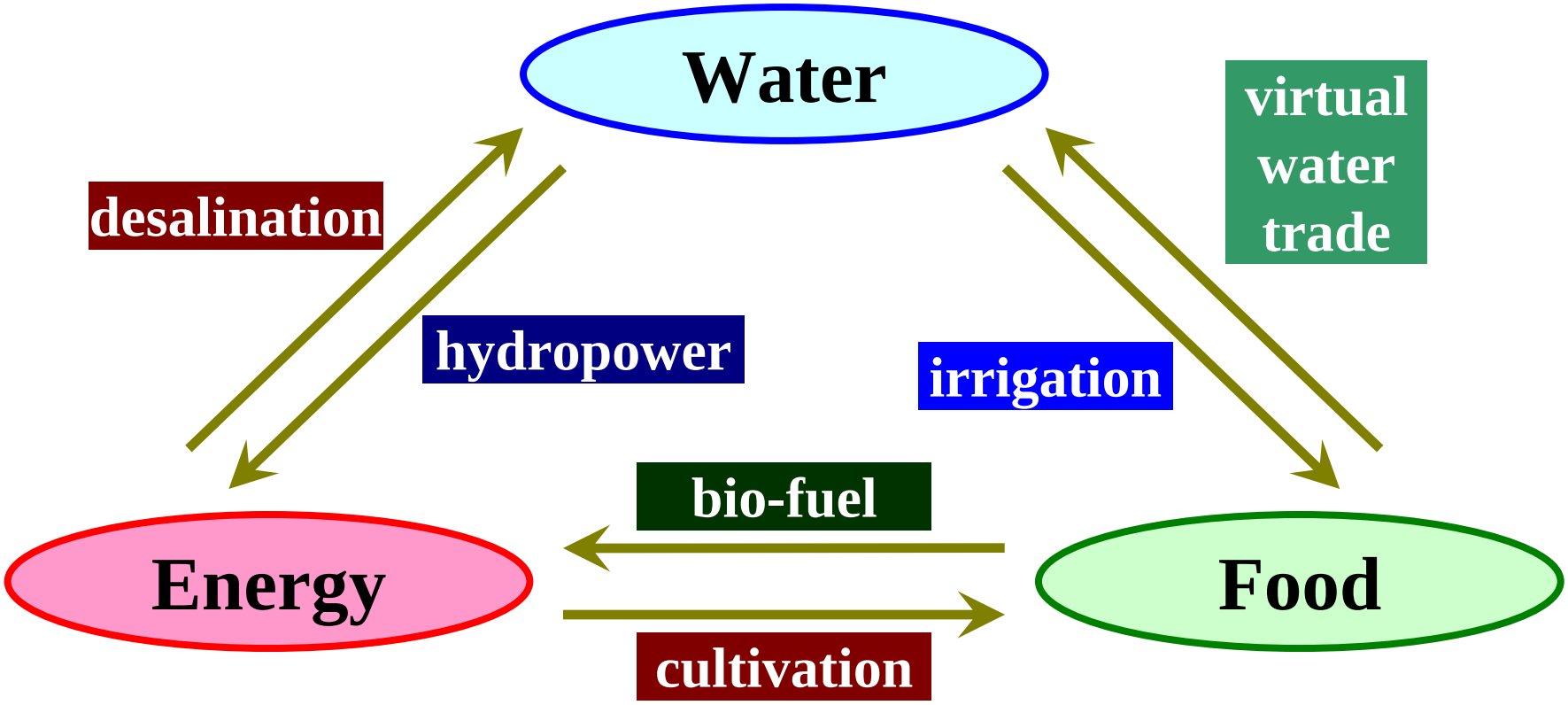
The same safety level will be assured with the "Climate Change Premium"

Magnitude of possible hazard (*e.g.*, flood level)

Capacity of counter measure to mitigate disaster (*e.g.*, dike height)

Support developing sustainability in a society

- Water should not be dealt alone separated from food and energy. ←**Limited Resources = "LAND"**



Messages

- **Scenario Projection:** (Oki and Kanae, *Science*, 2006)
  - **The ultimate objectives of future-oriented world water resource assessments are to show the international community what will happen if we continue to manage our water resources as we do today and to indicate what actions may be needed to prevent undesirable outcomes. In that sense, studies of future world water resources are successful if their predictions based on business-as-usual are proven wrong.**
- **Mitigation is also good for sustainable energy usage, and adaptation is also good for reduction of current vulnerabilities.**