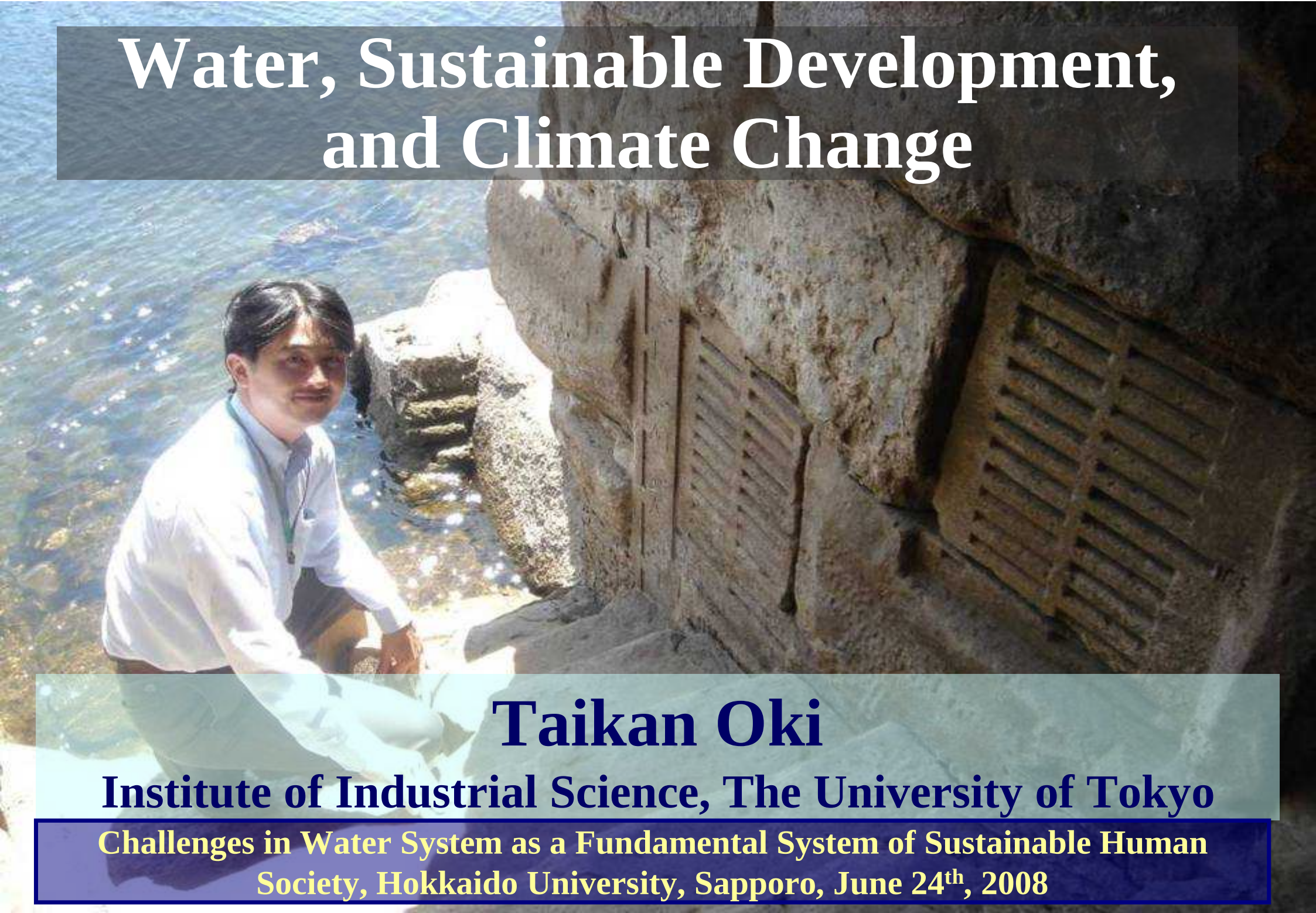
Water, Sustainable Development, and Climate Change



Taikan Oki

Institute of Industrial Science, The University of Tokyo

Challenges in Water System as a Fundamental System of Sustainable Human Society, Hokkaido University, Sapporo, June 24th, 2008


0 50 100 150 200
km
Nile Delta and Sinai Peninsula - February 29, 2000 - MODIS/MODLAND/Descloitres

World Water Issues

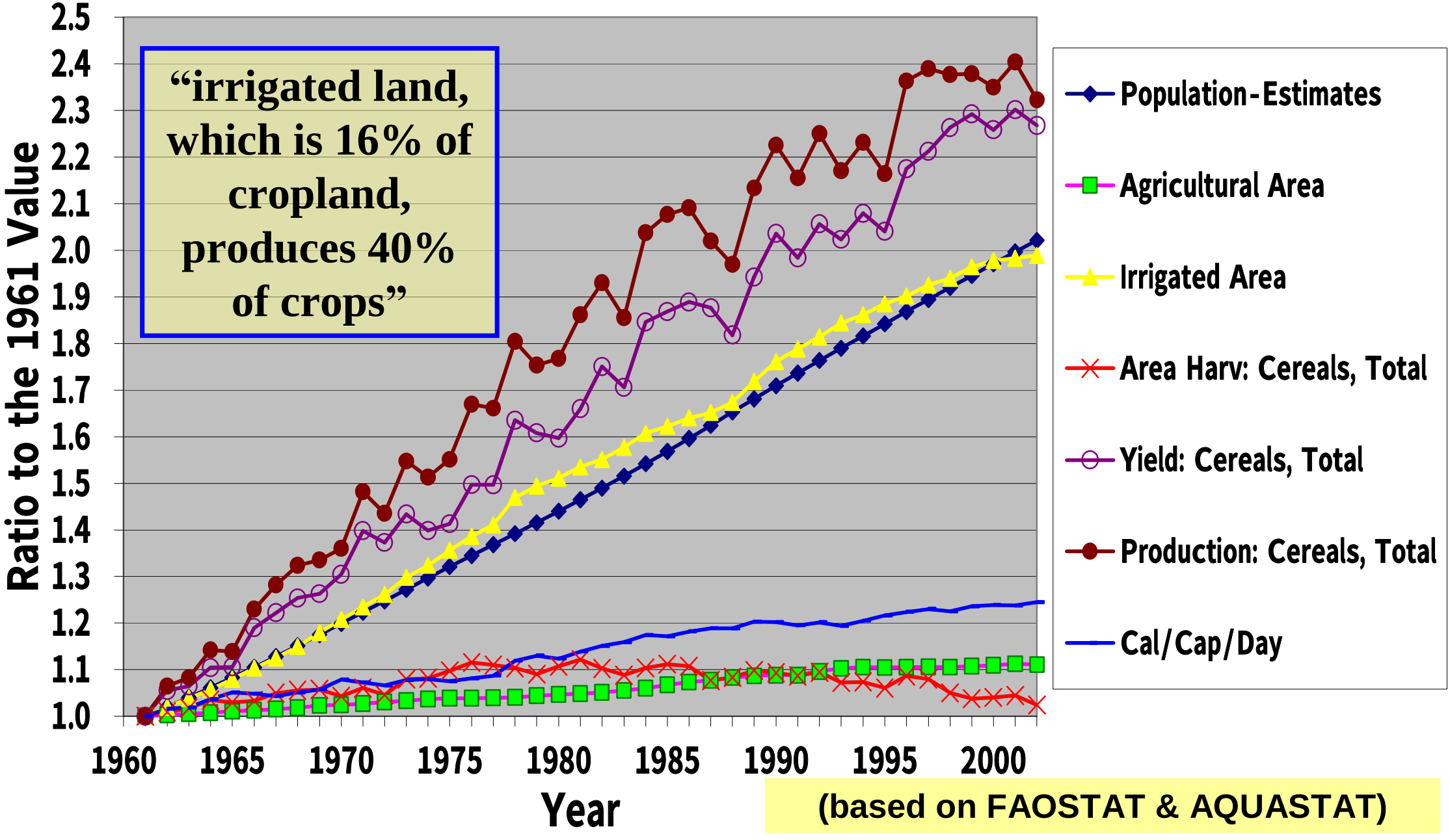
- **Indispensable water for lives**
  - ❄ **One in five of the world population does not have access to safe and affordable drinking water (20L/d/c within 1km).**
    - ➢ **Each year 3-4 million people die because of waterborne diseases**
- **Profitable water for agriculture and industry**
  - ❄ **Total 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)**

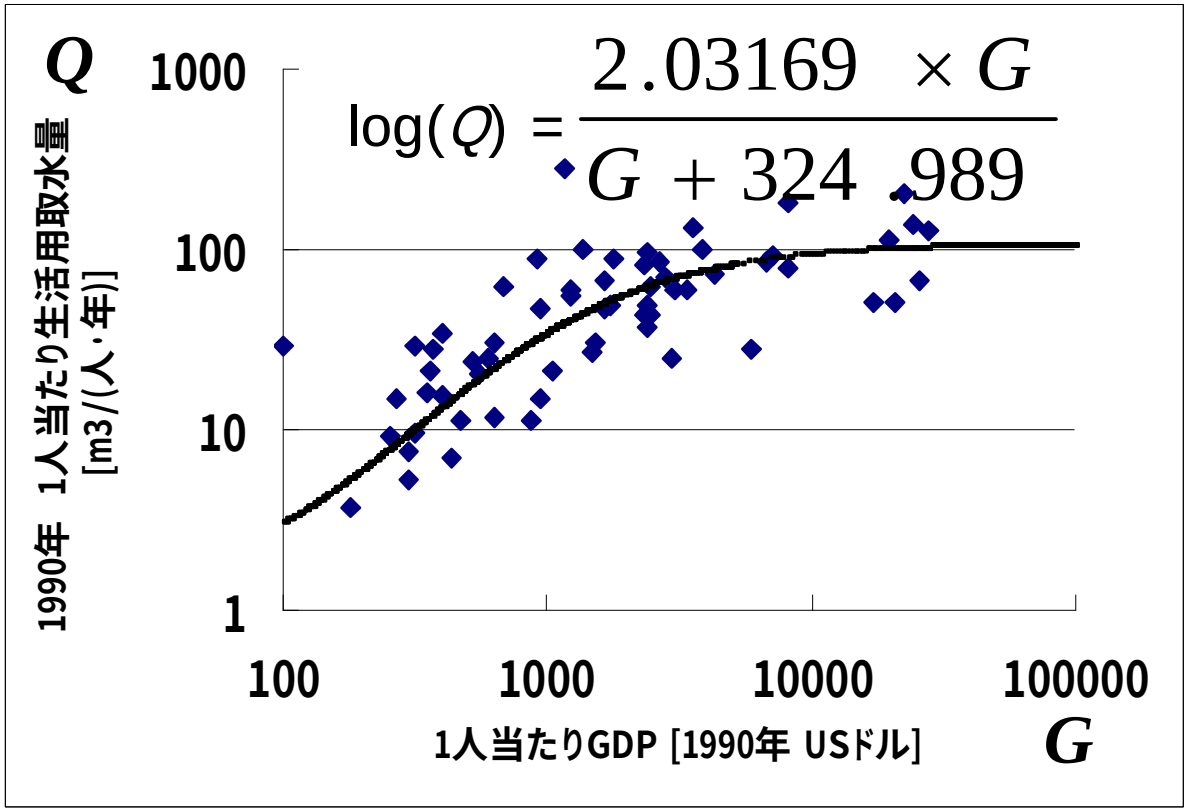
World Food Production and Supply



(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.

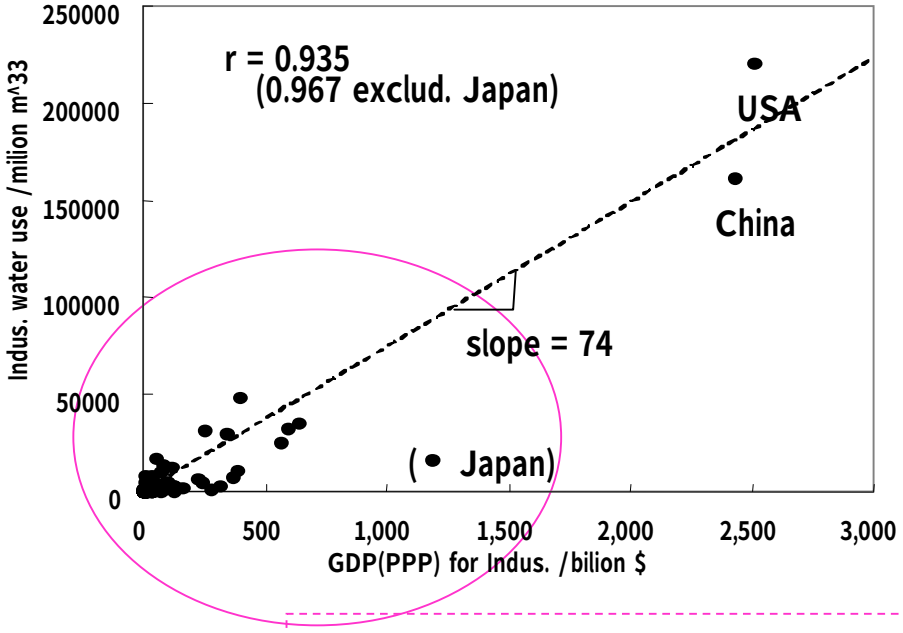
- Future Domestic Water Use= Future Estimate +D

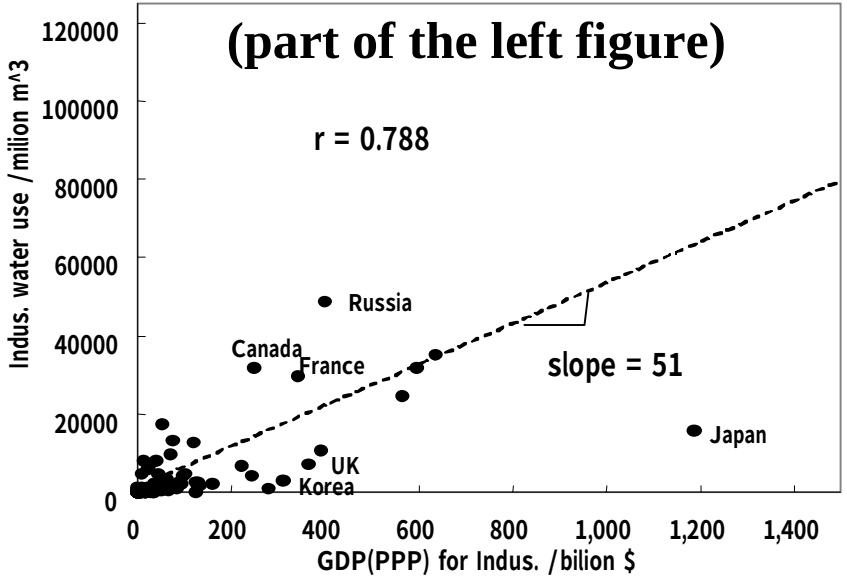
where D is the bias error,
D=Statistics in 1900 – Estimate for 1990

*** 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.



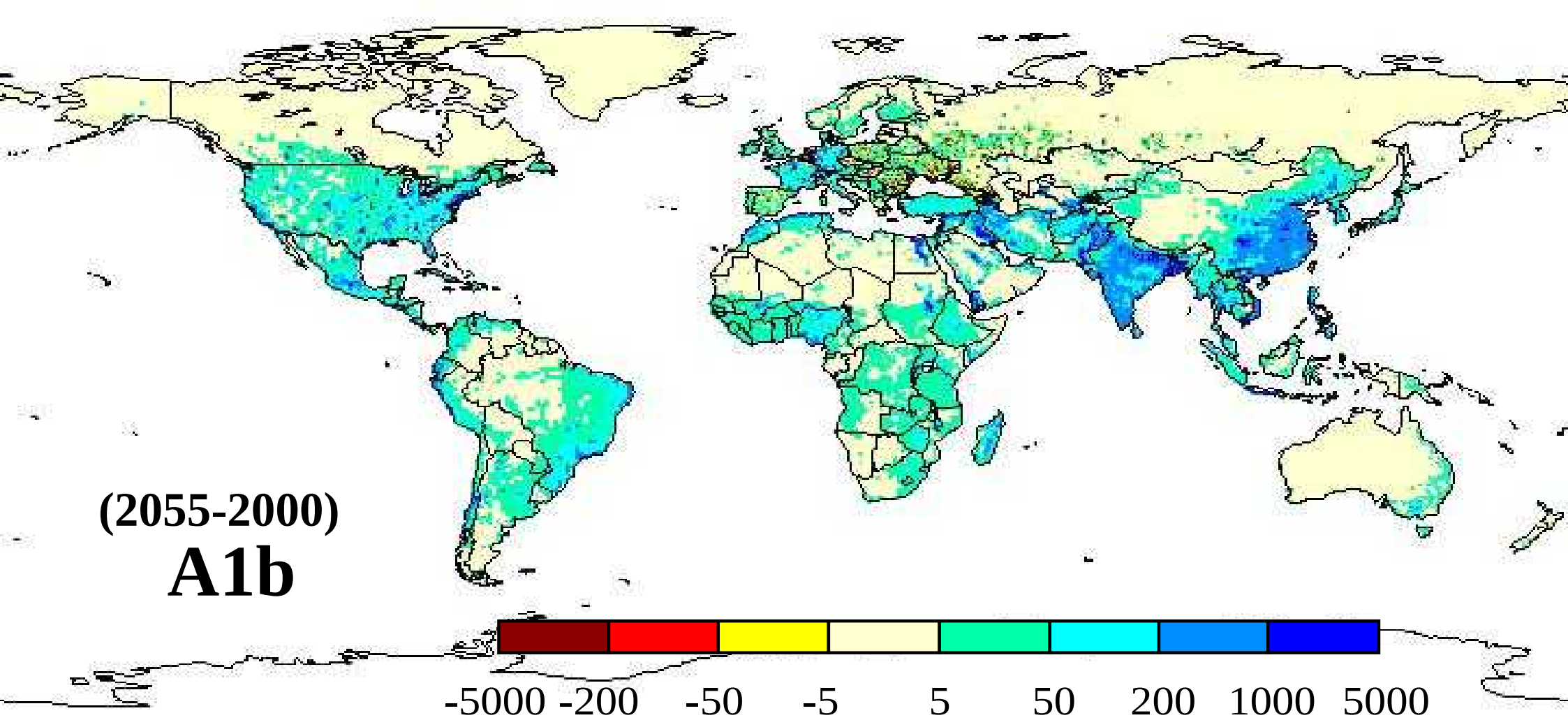


Japan is an exception with high water use efficiency.

Future Projection

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

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



(Shen, et. al, 2008, HSJ)

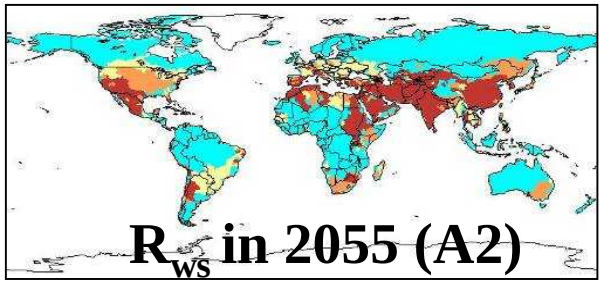
(Lead Authors for the 4th Assessment Report of the IPCC, WG II, Chapter 3 "Freshwater resources and their management")

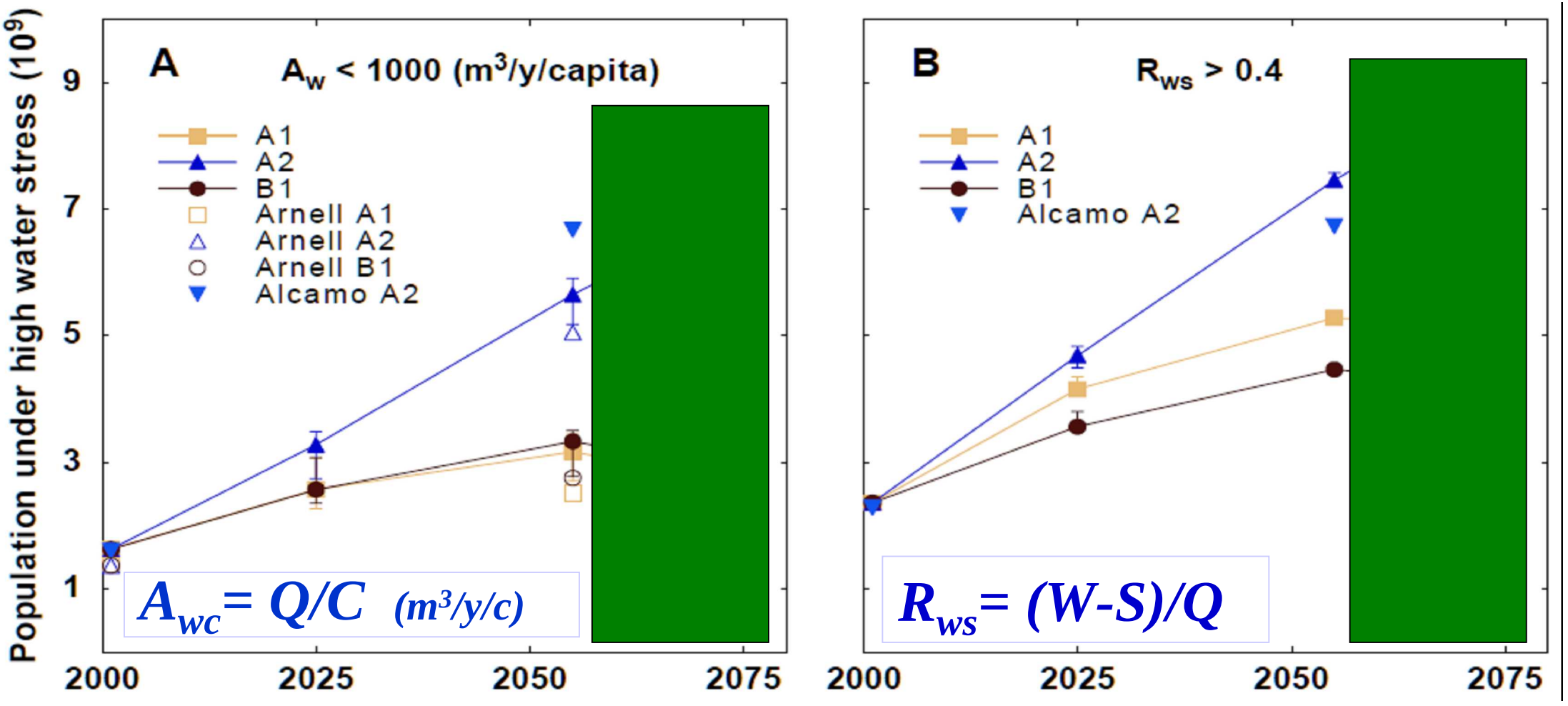
Impacts of climate change on freshwater fesources

- 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)

Number of people under serious water stress

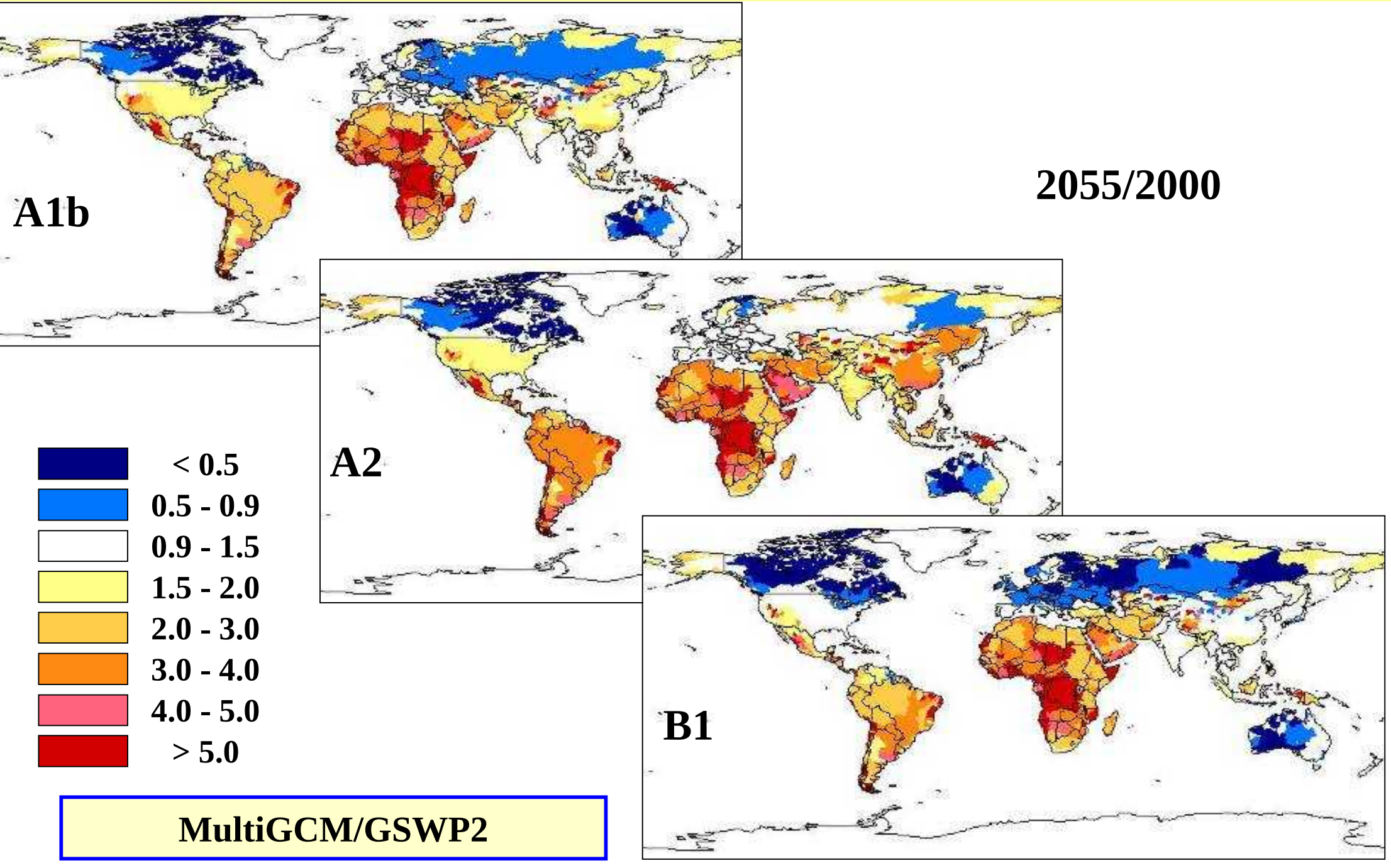




Q: How can we realize B1 society?

(Oki and Kanae, *Science*, 2006)

Change in water stress index for 2050 (ratio)




Extreme Events?

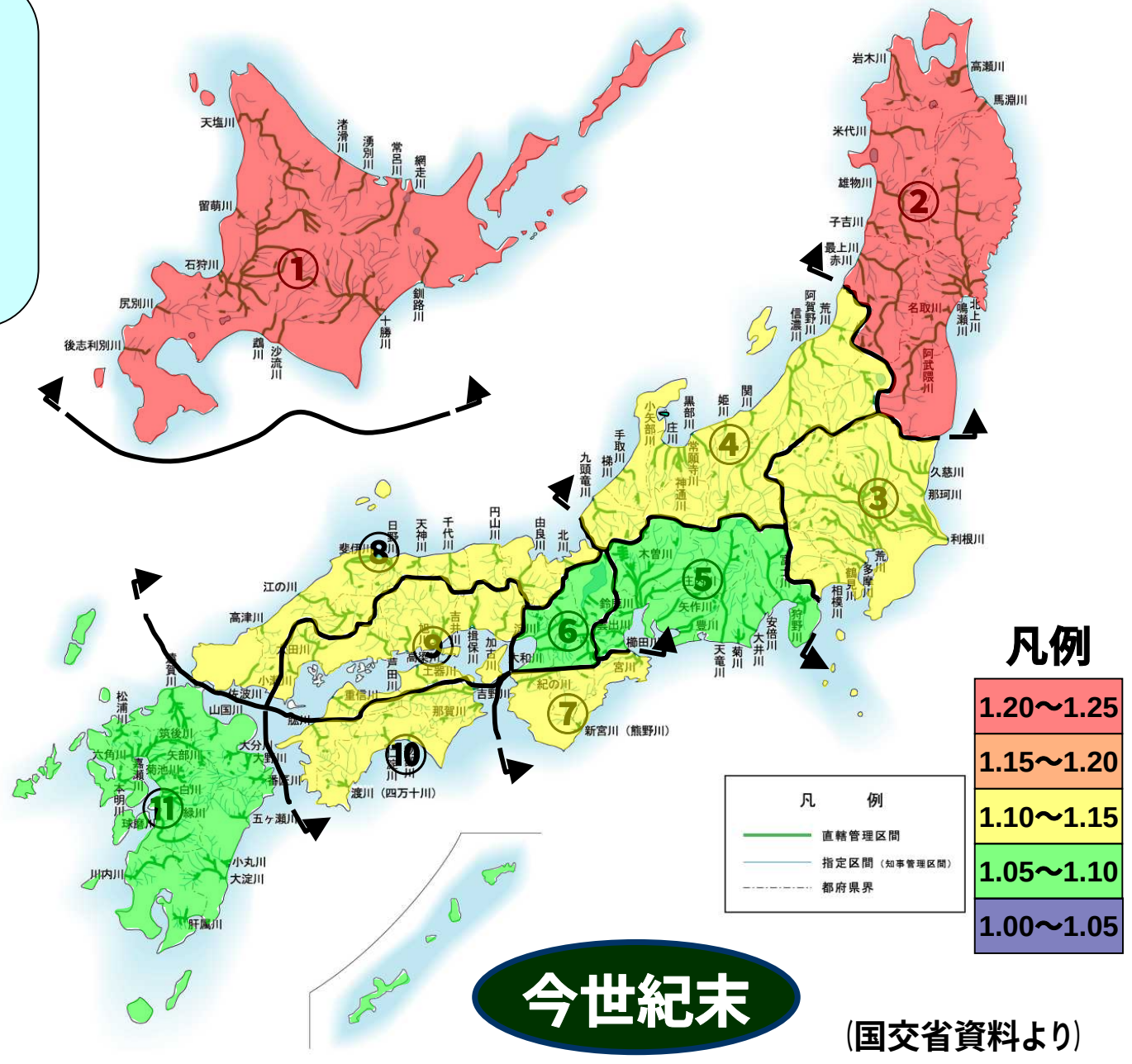
降雨量増加の地域分布　今世紀末でもせいぜい1.2倍程度

GCM20（A1Bシナリオ）で求めた
各調査地点の年最大日降水量から

$$\frac{\text{(2080-2099年の平均値)}}{\text{(1979-1998年の平均値)}}$$

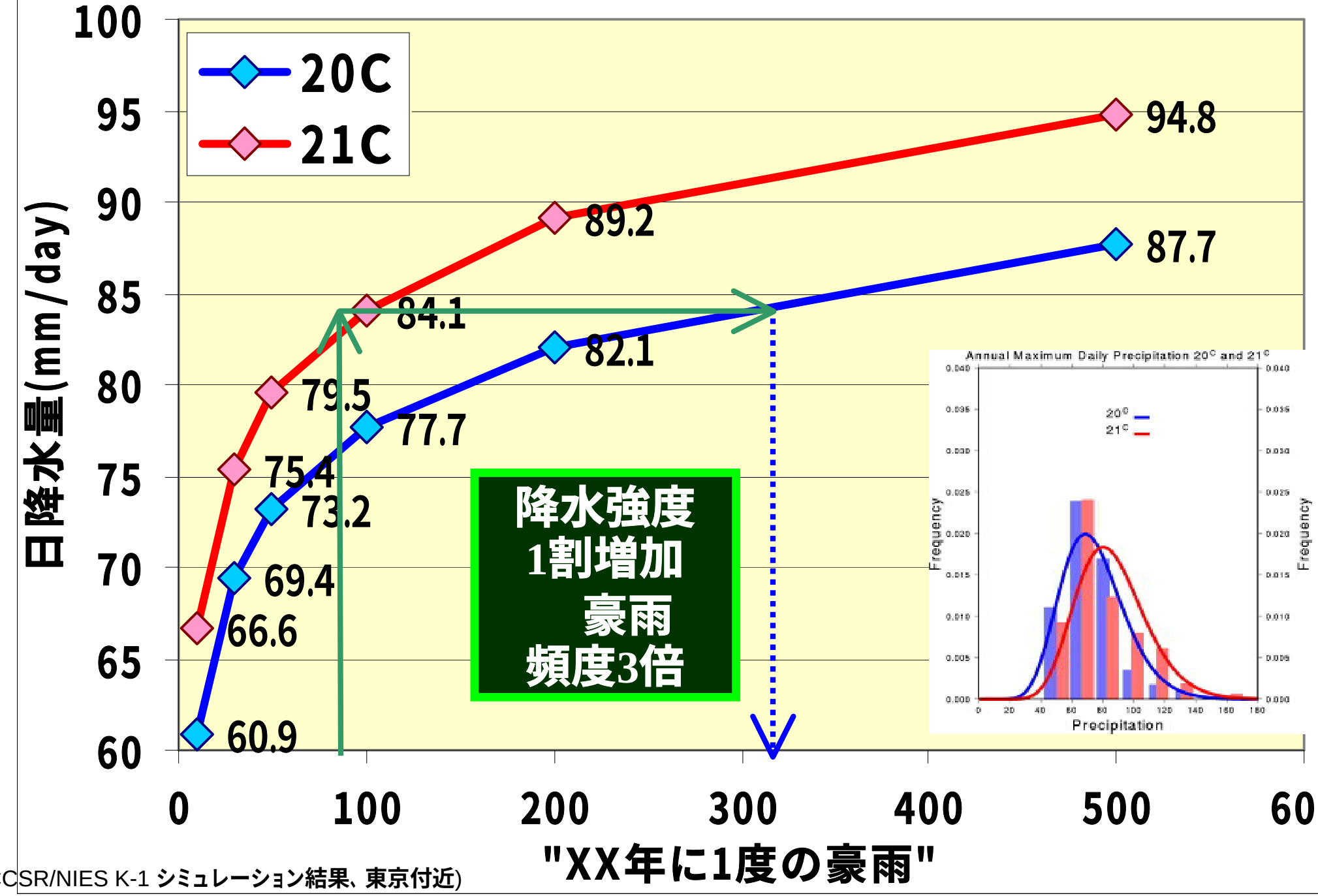
を求め
将来の降雨量を予測（上記の中位値）

①	北海道	1.24
②	東北	1.22
③	関東	1.11
④	北陸	1.14
⑤	中部	1.06
⑥	近畿	1.07
⑦	紀伊南部	1.13
⑧	山陰	1.11
⑨	瀬戸内	1.10
⑩	四国南部	1.11
⑪	九州	1.07



（国交省資料より）

X年確率降水量 (年最大日降水量)

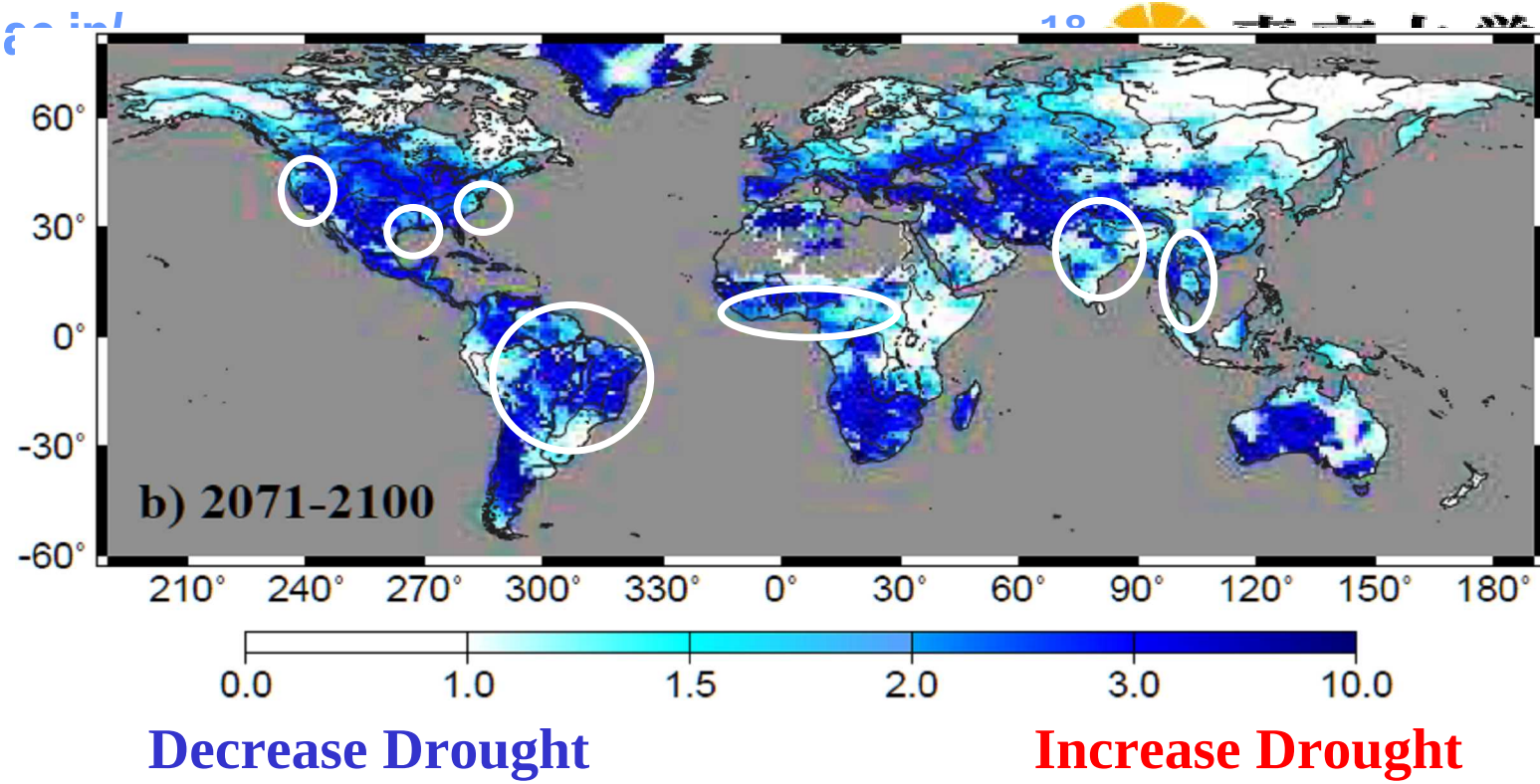


(CCSR/NIES K-1 シミュレーション結果、東京付近)

Change in Drought Frequency

End of 21st century compared with 20th century

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

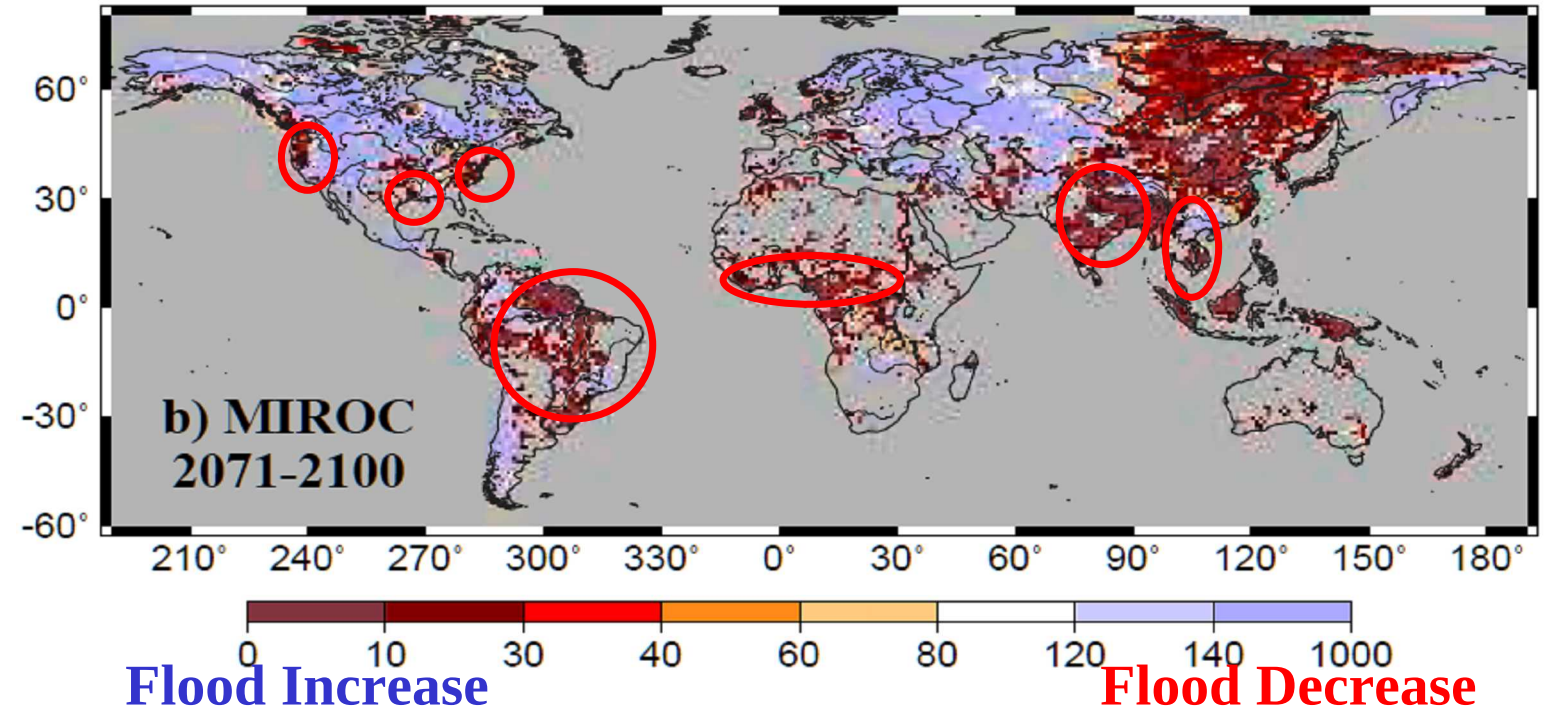


Decrease Drought **Increase Drought**

Change in Flood Frequency

End of 21st century compared with 20th century

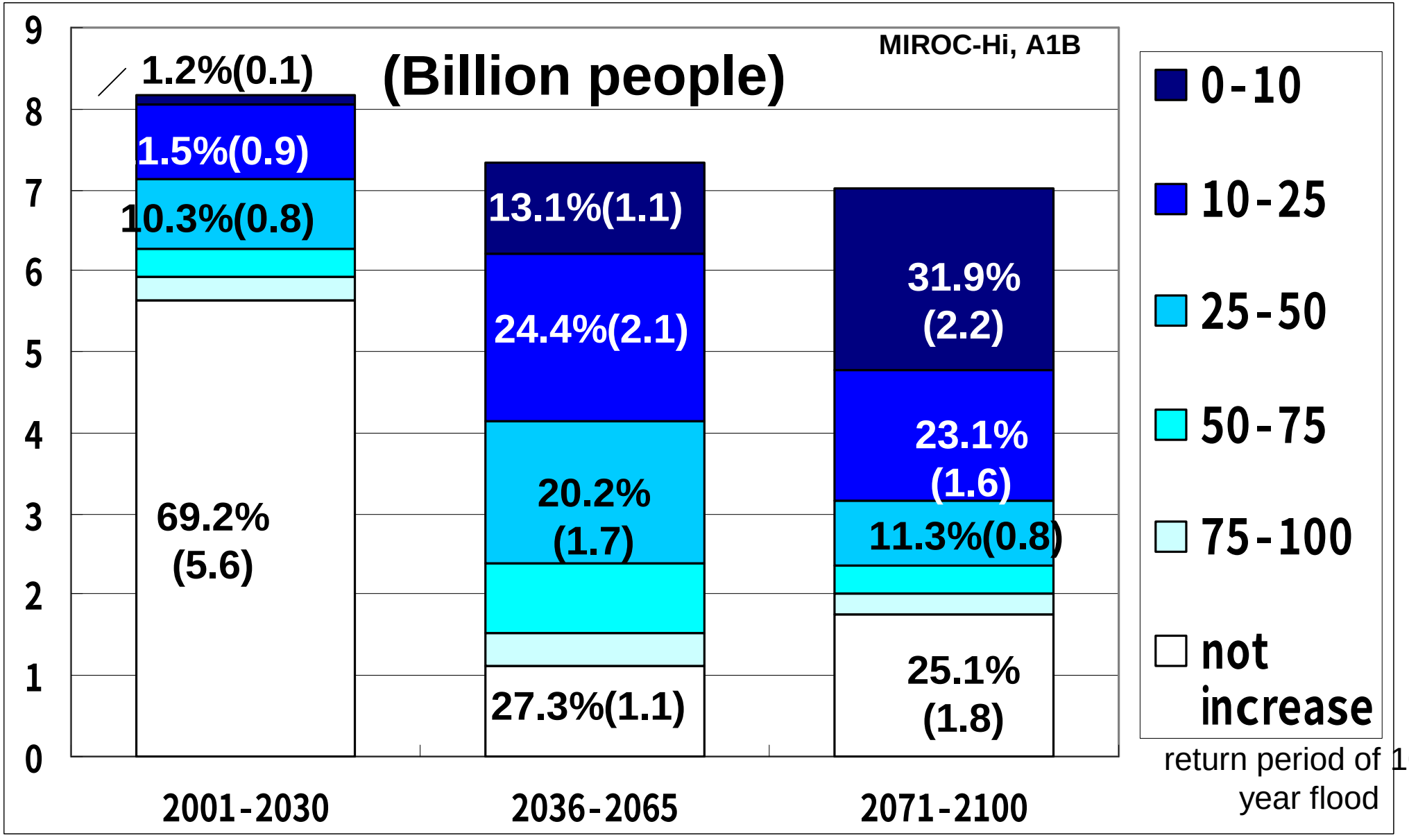
Frequency in the 21st century of 100-year flood in the 20th century



Flood Increase **Flood Decrease**

Hirabayashi et al., (*HSJ*, 2008)
Based on CCSR-NIES AOGCM

Number of people under more frequent floods



(Hirabayashi et al. 2008, HSJ)

Counter Measure against CC

- **Mitigation**
  - ❄ **Reduce the emission of green house gases (GHGs) and slow down the speed of the climate change.**
  - ❄ **Most of the measures are also good for reducing the energy consumption and saving the fossil energy.**
- **Adaptation**
  - ❄ **Enhance the resilience of the society and reduce the disaster which is anticipated due to the climate change.**
  - ❄ **Most of the adaptation measures are also good for solving the existing social issues: poverty, vulnerabilities for natural disaster, food and agriculture, health, ecosystem, …**

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)


Naha, Okinawa, Japan
40,000m3/day
24 11:41AM

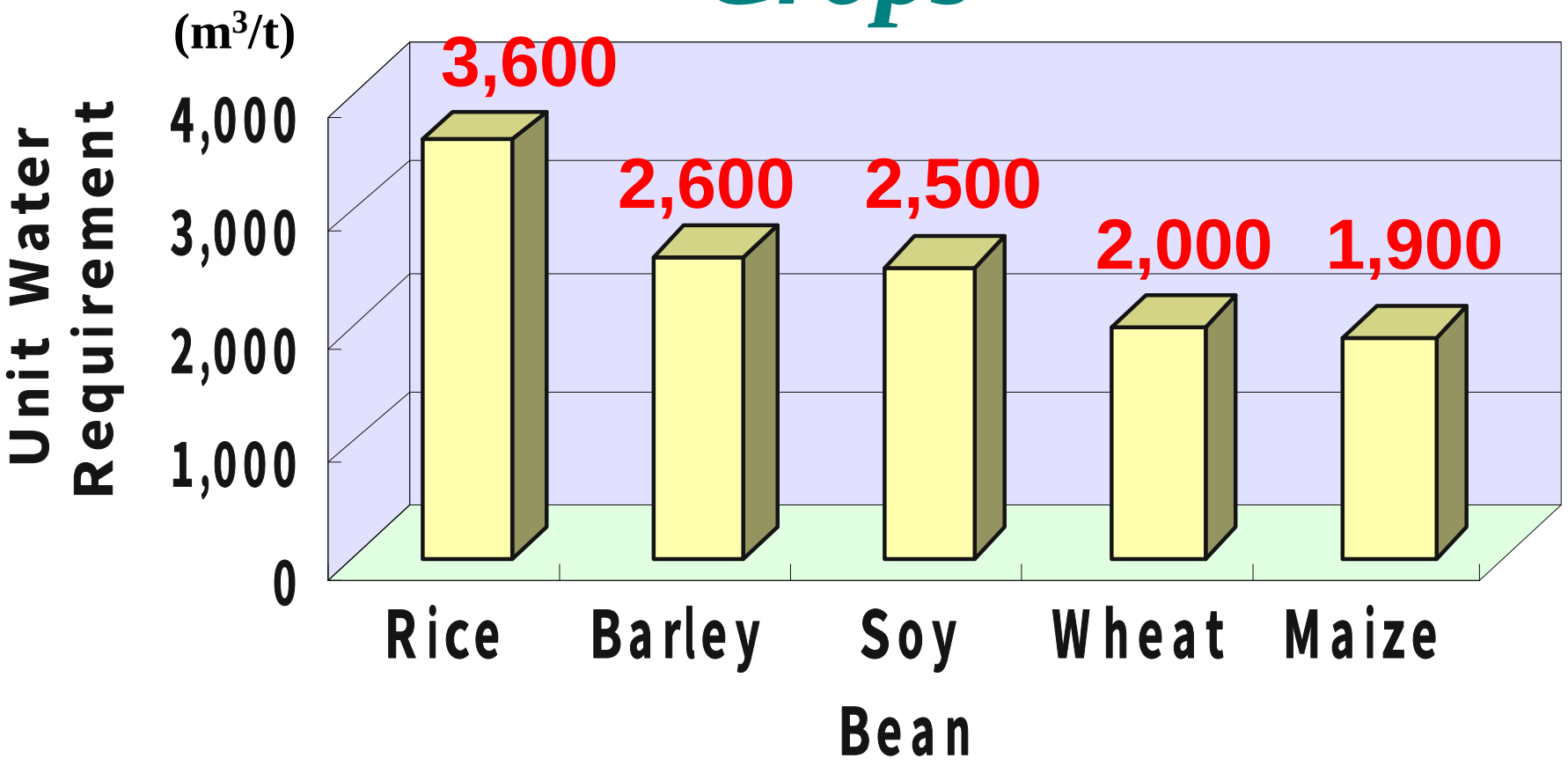
Adaptation Options

- **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**
  - **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**
  - **Reduction in water demand for irrigation by importing agricultural products, i.e., virtual water**

(IPCC AR4, WGII Ch3, 2007)

Unit Requirement of Water

--Crops--

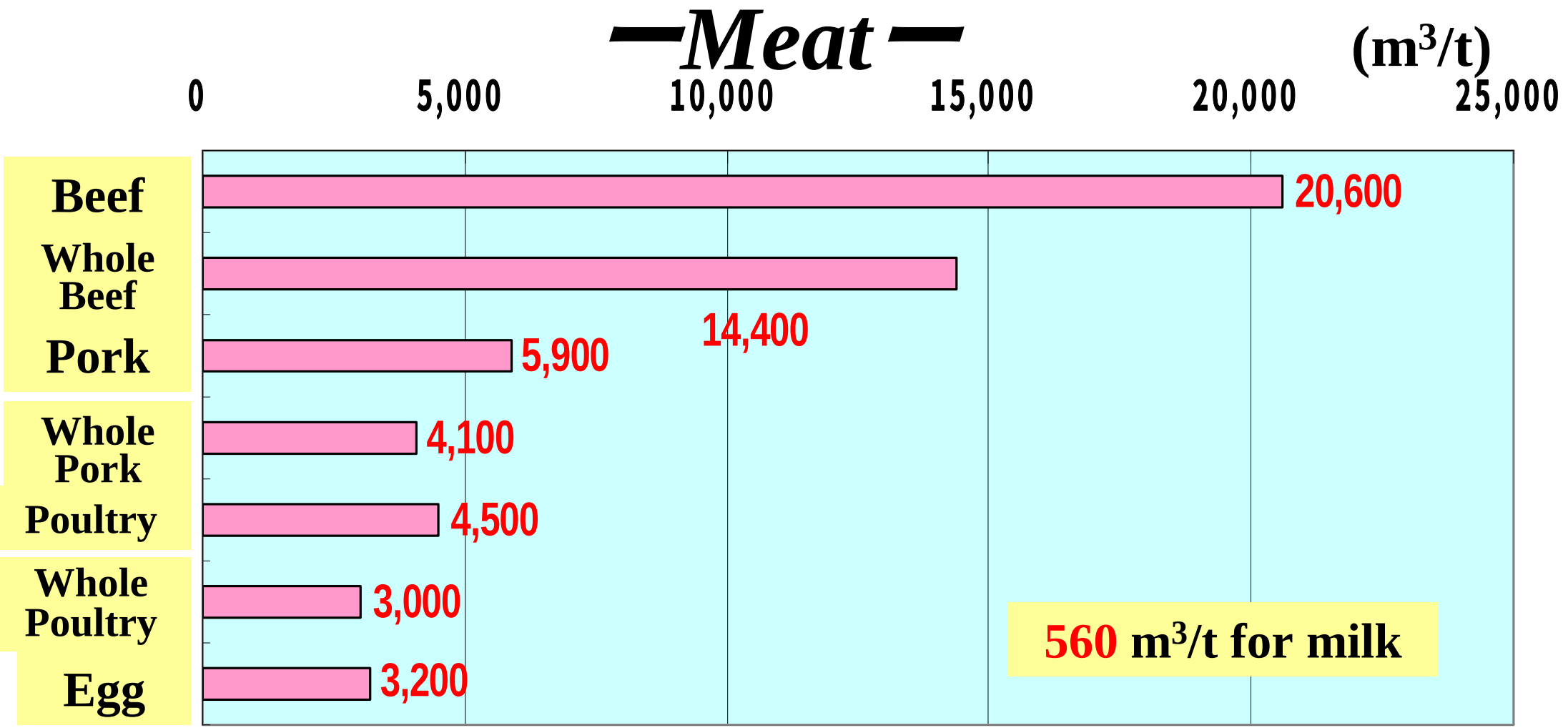


Unit Water Requirement of Major Crops

(based on crop yield in Japan、FAOSTAT mean 1996-2000)

(Oki, et. al, 2002, IHE-UNESCO)

Unit Water Requirement

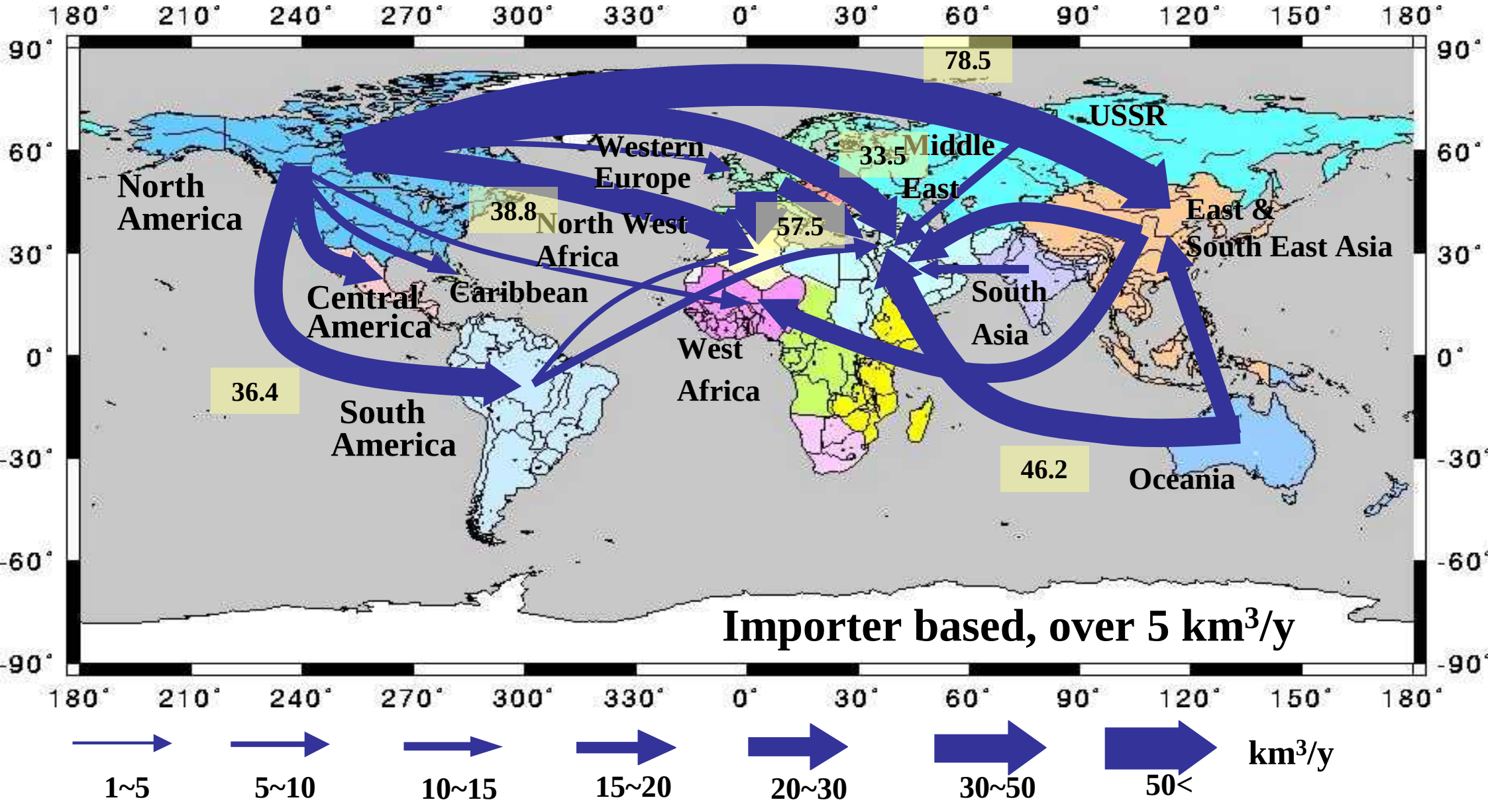


Unit Water Requirement of Major Meat

(based on crop yield and the way of raising in Japan)

(Oki, et. al, 2002, IHE-UNESCO)

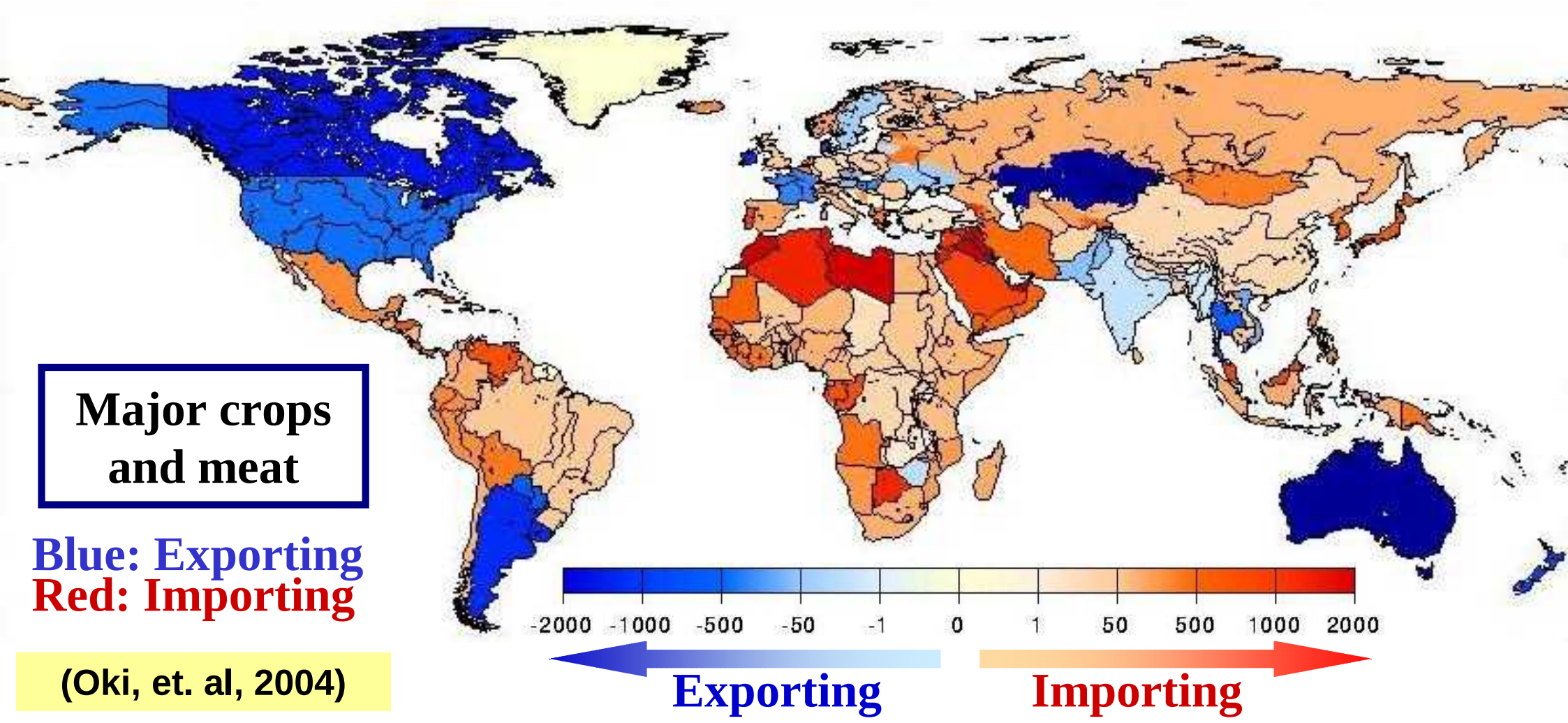
"Virtually Required Water" Trade between Regions associated with food trade in 2000 (cereals only)



(Oki, et. al, 2004)

(Based on Statistics from FAO etc., for 2000)

Virtual Water Balance in Countries (m^3/c/y) in 2000



Major crops and meat

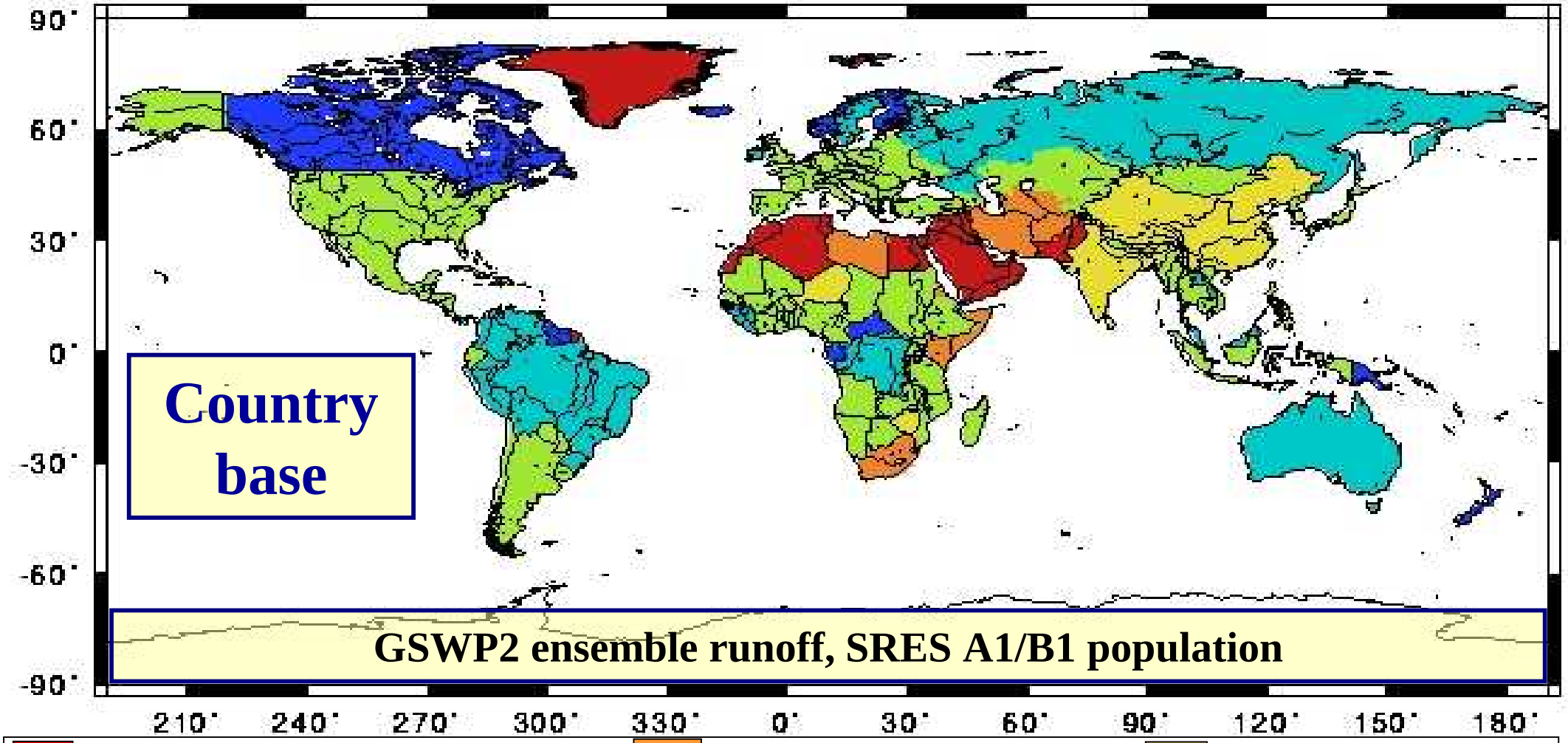
Blue: Exporting
Red: Importing

(Oki, et. al, 2004)

- **7 out of top 10 importing countries are seriously poor in water resources.**
- **7 out of top 10 exporting countries are rich in water resources.**
- **Denmark (10) and India (18) are water stressed but exporting *RW* in net.**

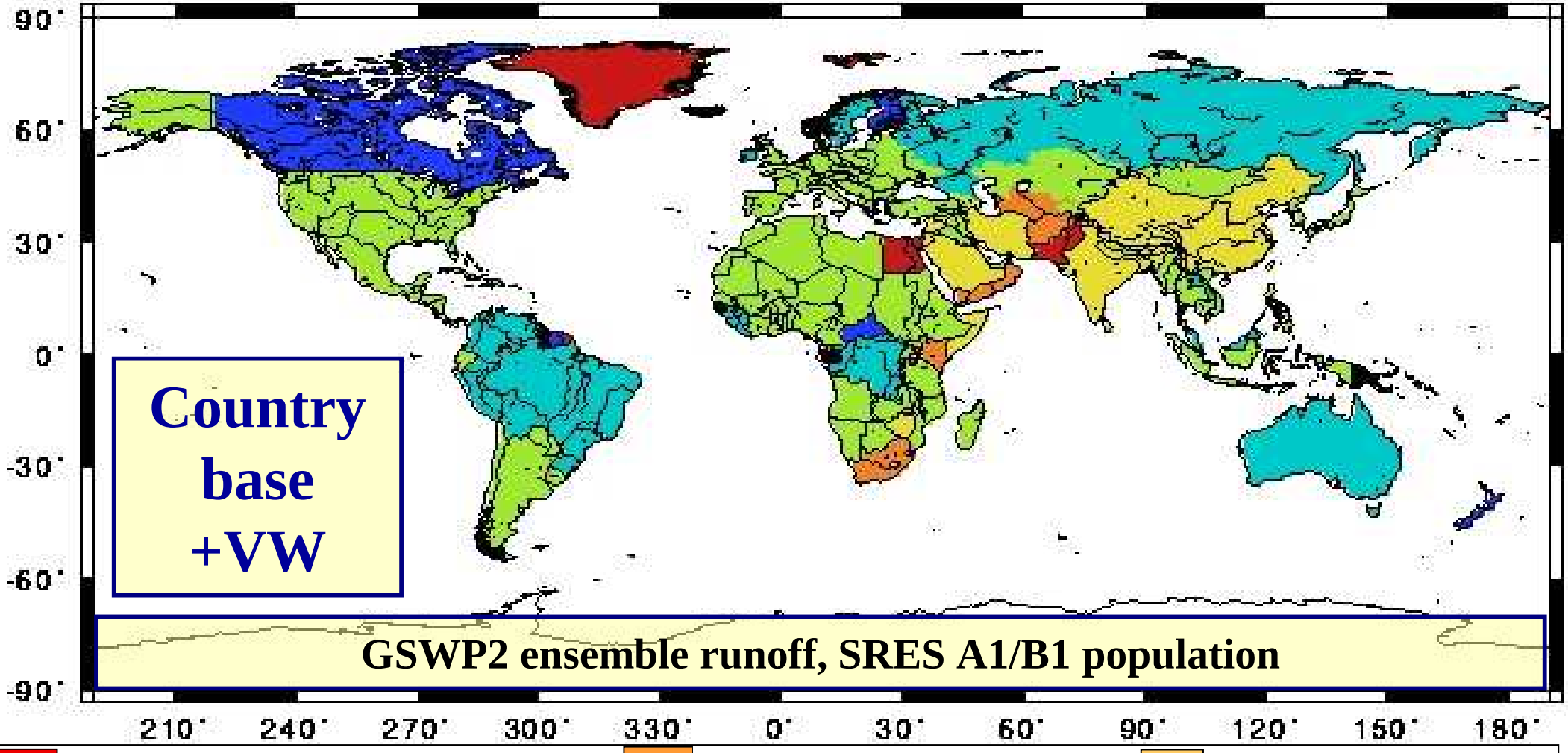
Conventional Water Resources Assessment

Potentially Available Water Resources per Capita in 2000



World Water Resources Considering Virtual Water Trade

Potentially Available Water Resources per Capita in 2000



Seriously Stressed (~1)

Stressed (1~2)

Slightly Stressed (2~5)

Moderate (5~10)

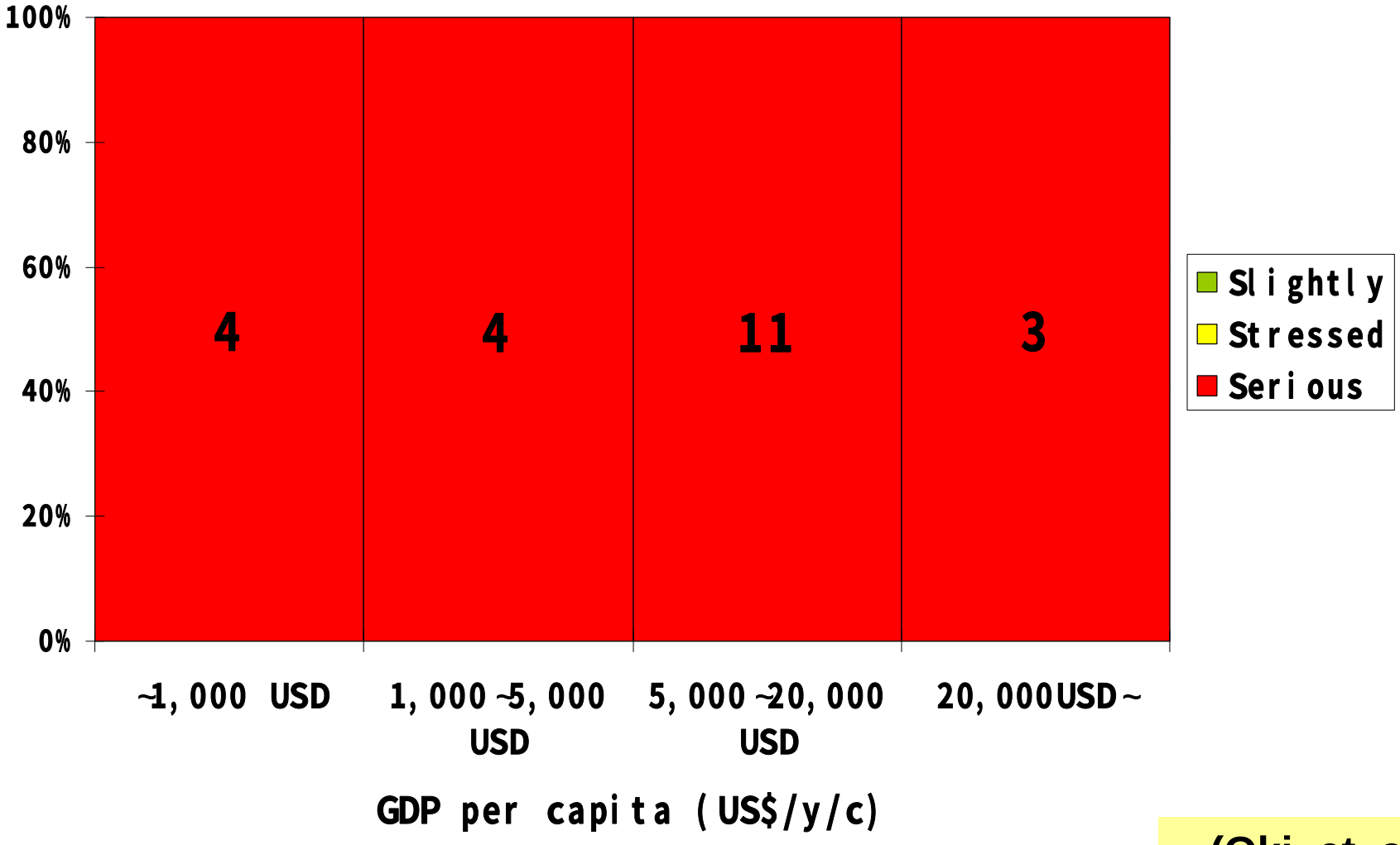
Rich (10~)

10^3 m^3/capita/year

Water Resources Assesment Considering VW trade

22 Countries were classified into "seriously stressed" in 2000 by conventional water resources assessment.

➔ +Virtual Water Import



(Oki, et. al, 2004)

Water Resources Assesment Considering VW trade

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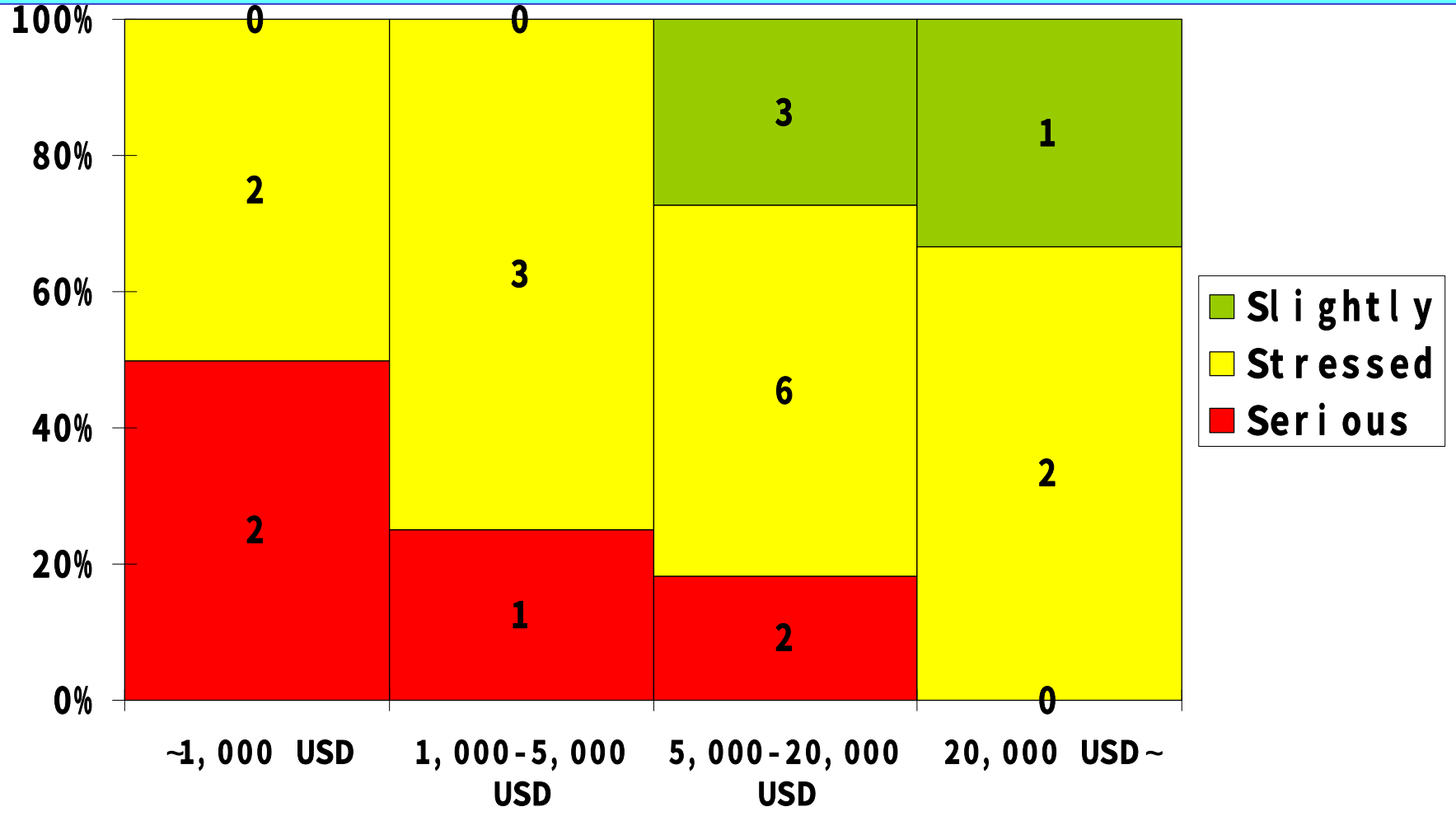

(Oki, et. al, 2004)

Water Resources Assesment Considering VW trade

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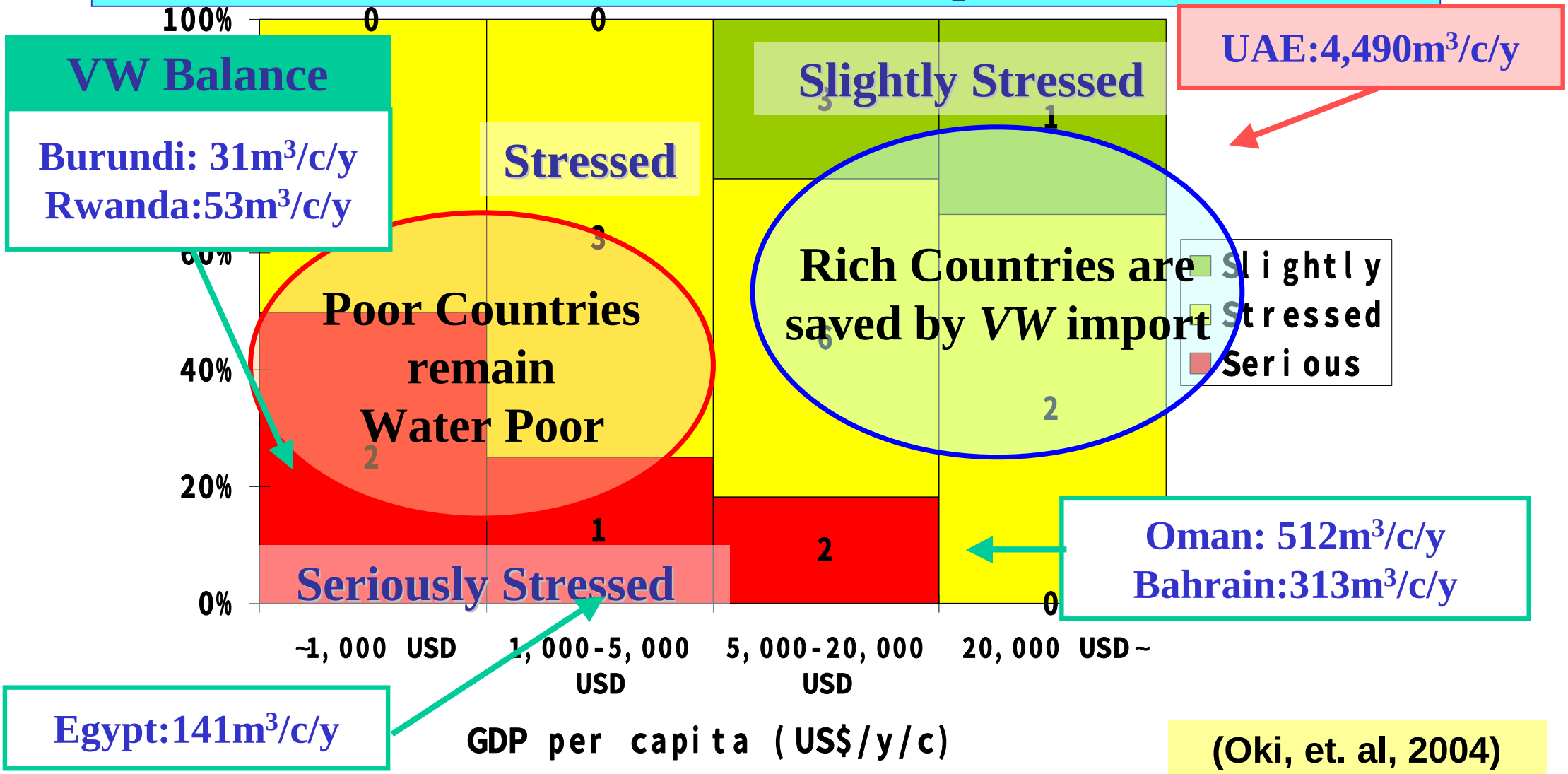


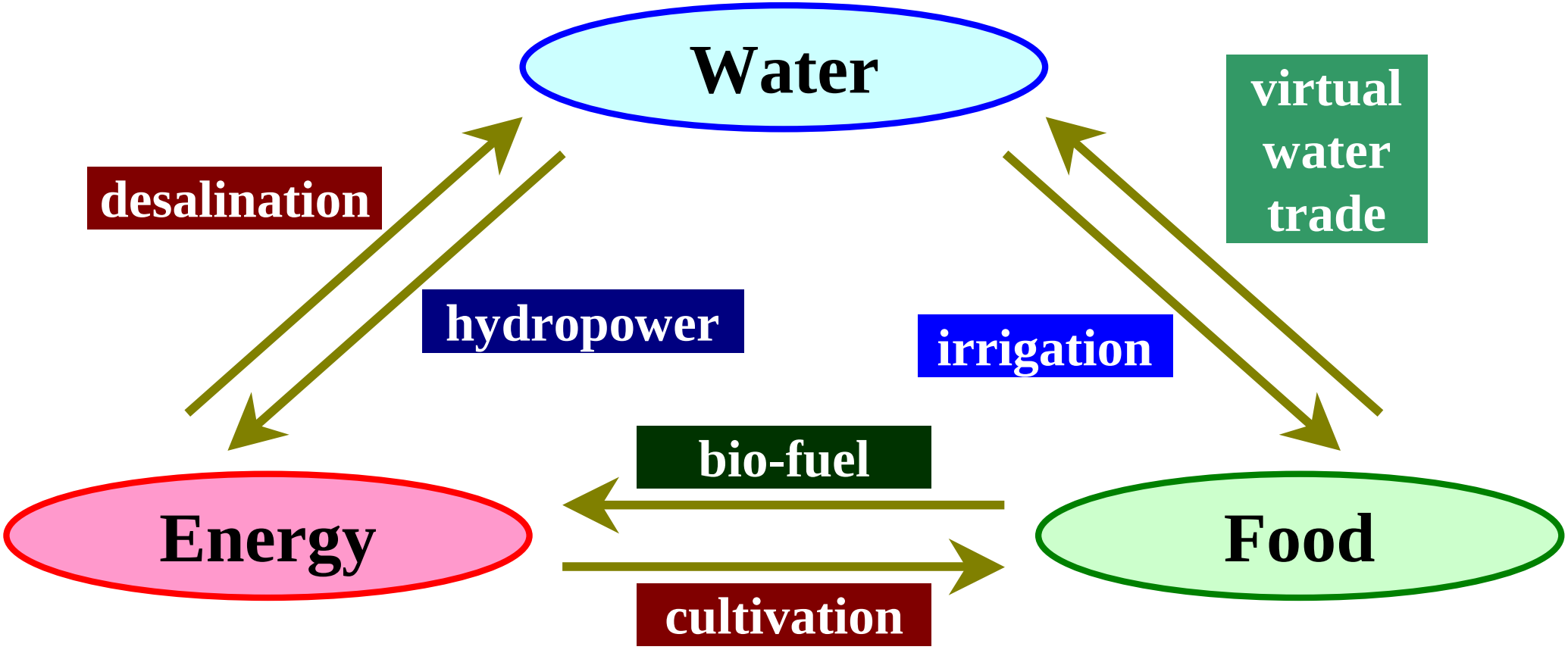
(Oki, et. al, 2004)

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 reducing of current vulnerabilities against hazards.**

Support developing sustainability in a society

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



飲水思源

When you drink water,
think its origin.

飲食思水

When you eat,
think about water.

Thank You!!