Millennium Ecosystem Assessment

The Changing Balance of Nature:
Findings from the Millennium Ecosystem Assessment

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Peyresq, France 20.09.05

Millennium Ecosystem Assessment

Part A The Millennium Ecosystem Assessment: Main findings of the first comprehensive global assessment of nature

Part B The WaterGAP model: Global modeling for global assessments

Millennium Ecosystem Assessment

Part A The Millennium Ecosystem Assessment:

Main findings of the first comprehensive global assessment of nature

Millennium Ecosystem Assessment

Goals of millennium ecosystem assessment

Create a mechanism to increase the amount, quality, and credibility of policy-relevant, scientific research findings concerning *ecosystems & human well-being* used by decision-makers, particularly those involved in the ecosystem-related conventions.

Millennium Ecosystem Assessment

Largest assessment of the status of Earth's ecosystems

Experts and Review Process

- Prepared by 1360 experts from 95 countries
- 80-person independent board of review editors
- Review comments from 850 experts and governments
- Includes information from 33 sub-global assessments

Governance

- Called for by UN Secretary General in 2000
- Authorized by governments through 4 conventions (Biodiversity, Climate, Desertification, Wetlands).

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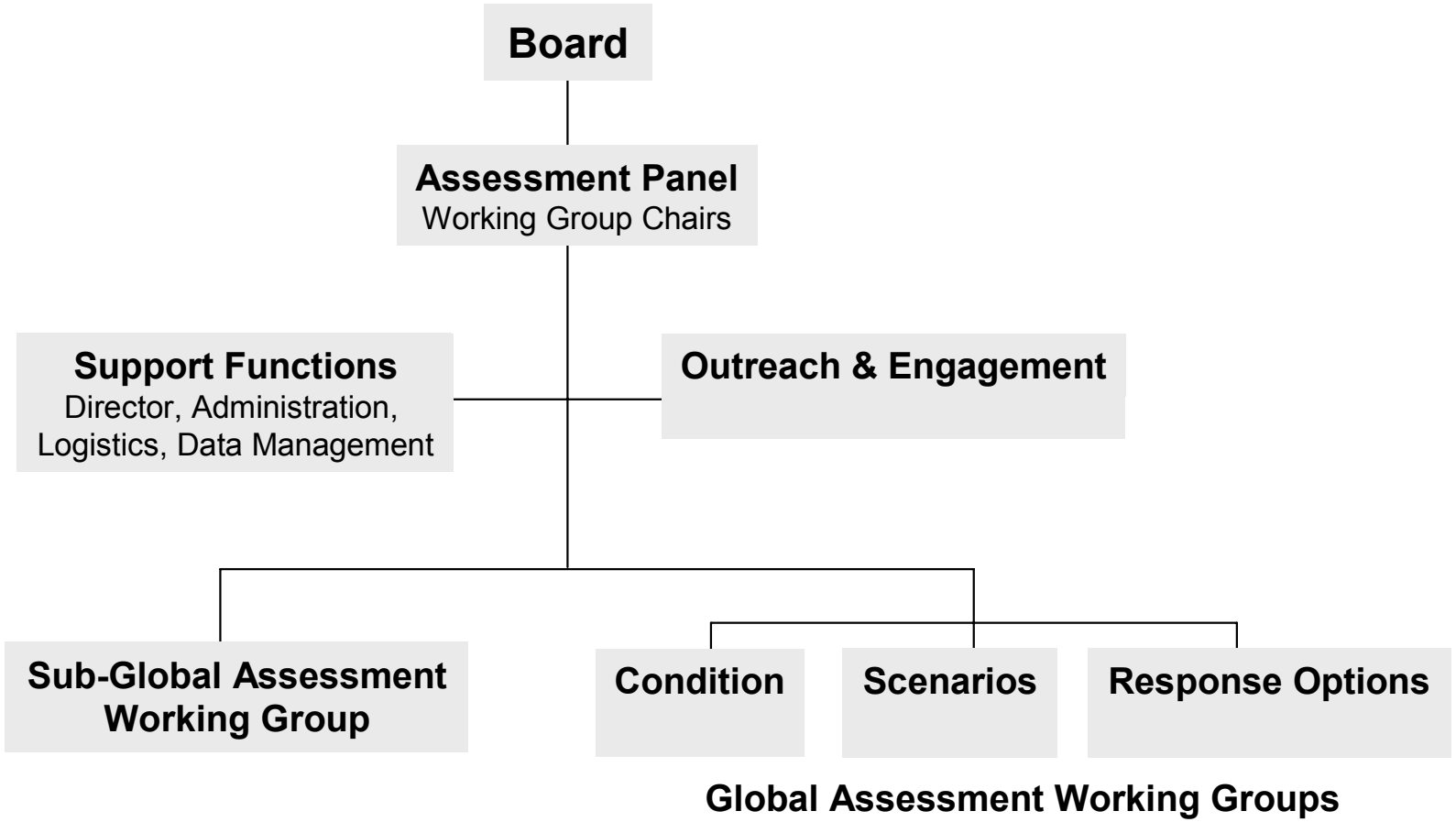
Organization



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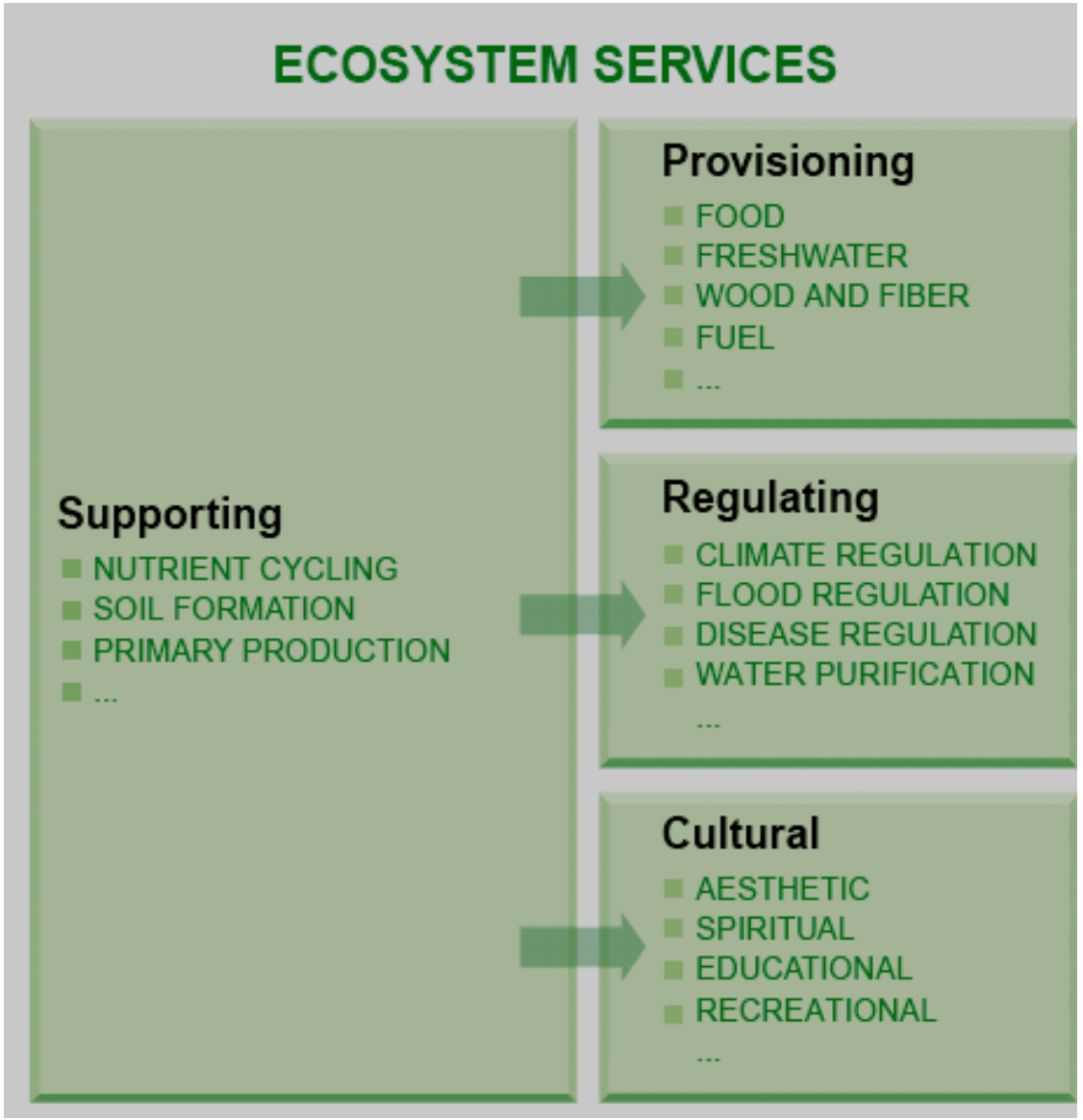
Definition of ecosystem services:
The benefits society derives from ecosystems



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The MA Assessment of Condition of Ecosystems Services

Findings ...

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Increases in ecosystem services have brought substantial gains in human well being

Since 1960, population doubled, economic activity increased 6-fold, food production increased 2 ½ times, food price has declined, water use doubled, wood harvest for pulp tripled, hydropower doubled.

But gains achieved at growing costs that could diminish the benefits that future generations obtain from ecosystems

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Cost of increased ecosystem services:

(i) Unprecedented change in ecosystems

Since 1945:
More land converted to cropland than in 18th and 19th centuries combined

Over last several decades:
20% of the world's coral reefs lost, 20% degraded

Over last several decades:
35% of mangrove area lost

Since 1960:
Amount of water in reservoirs quadrupled
Withdrawals from rivers and lakes doubled

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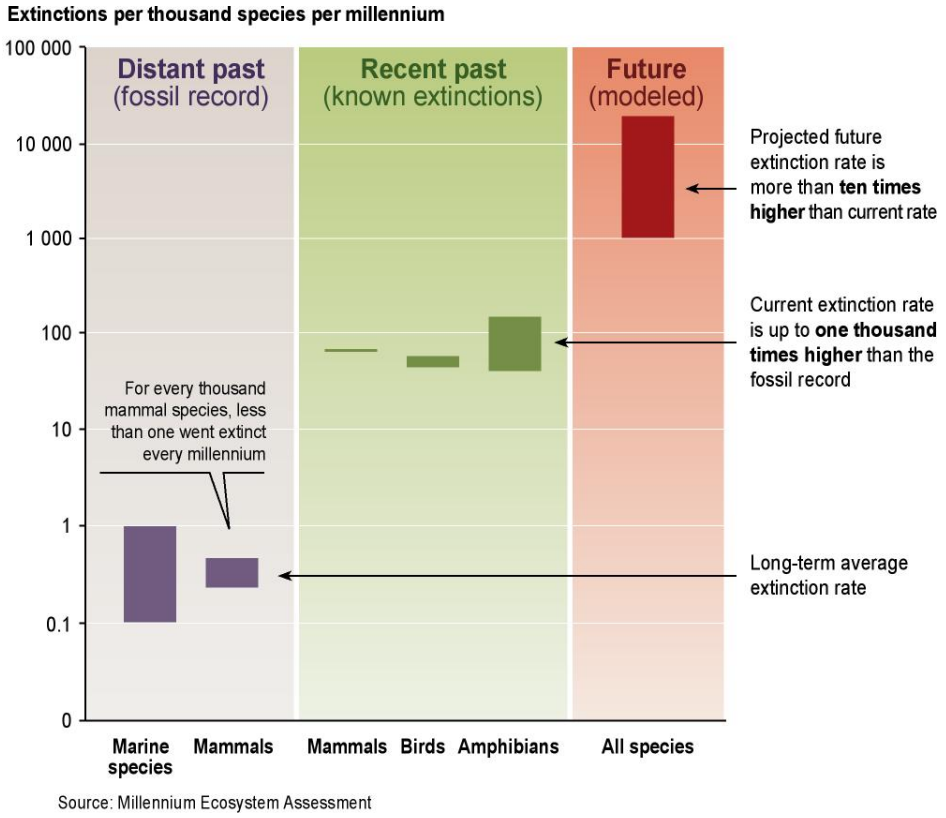
Cost of increased ecosystem services:
(ii) Significant and largely irreversible changes to species diversity

- The distribution of species more homogenous
- Humans increase species extinction rate by as much as 1,000 times over background rates (*medium certainty)*
- 10–30% of mammal, bird, and amphibian species currently threatened with extinction (*medium to high certainty)*

Extinctions / 1000 species / 1000 years



Source: Millennium Ecosystem Assessment

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Cost of increased ecosystem services: **(iii) Degradation and unsustainable use of ecosystem services**

- ↘ 60% (15 out of 24) of ecosystem services are being degraded or used unsustainably
- Degradation of ecosystem services often causes significant harm to human well-being

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Cost of increased ecosystem services: **(iv) Degradation of ecosystem services harms people**

- ½ urban population in Africa, Asia, Latin America, and the Caribbean suffers from one or more diseases associated with inadequate water and sanitation
- Decline of freshwater fisheries reduce inexpensive source of protein in developing countries.
- Desertification destroys livelihoods of millions of people, including a large portion of the poor in drylands

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The MA Assessment of Condition of Ecosystems Services

Main Findings ...

Increases in ecosystem services have brought substantial gains in human well being

Cost of increased ecosystem services:

-- Unprecedented change in ecosystems

-- Significant and largely irreversible changes to species diversity

-- Degradation and unsustainable use of ecosystem services which harms society

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The Future of Ecosystem Services
The MA Global Scenario Analysis

Objectives

1) To assess magnitude and direction of changes in ecosystem services up to 2050 (2100) and their reliability.
2) To investigate effect of different developments in population, economy, technology and societal values on changes in ecosystem services.
3) To develop preliminary ideas about effective future policies.

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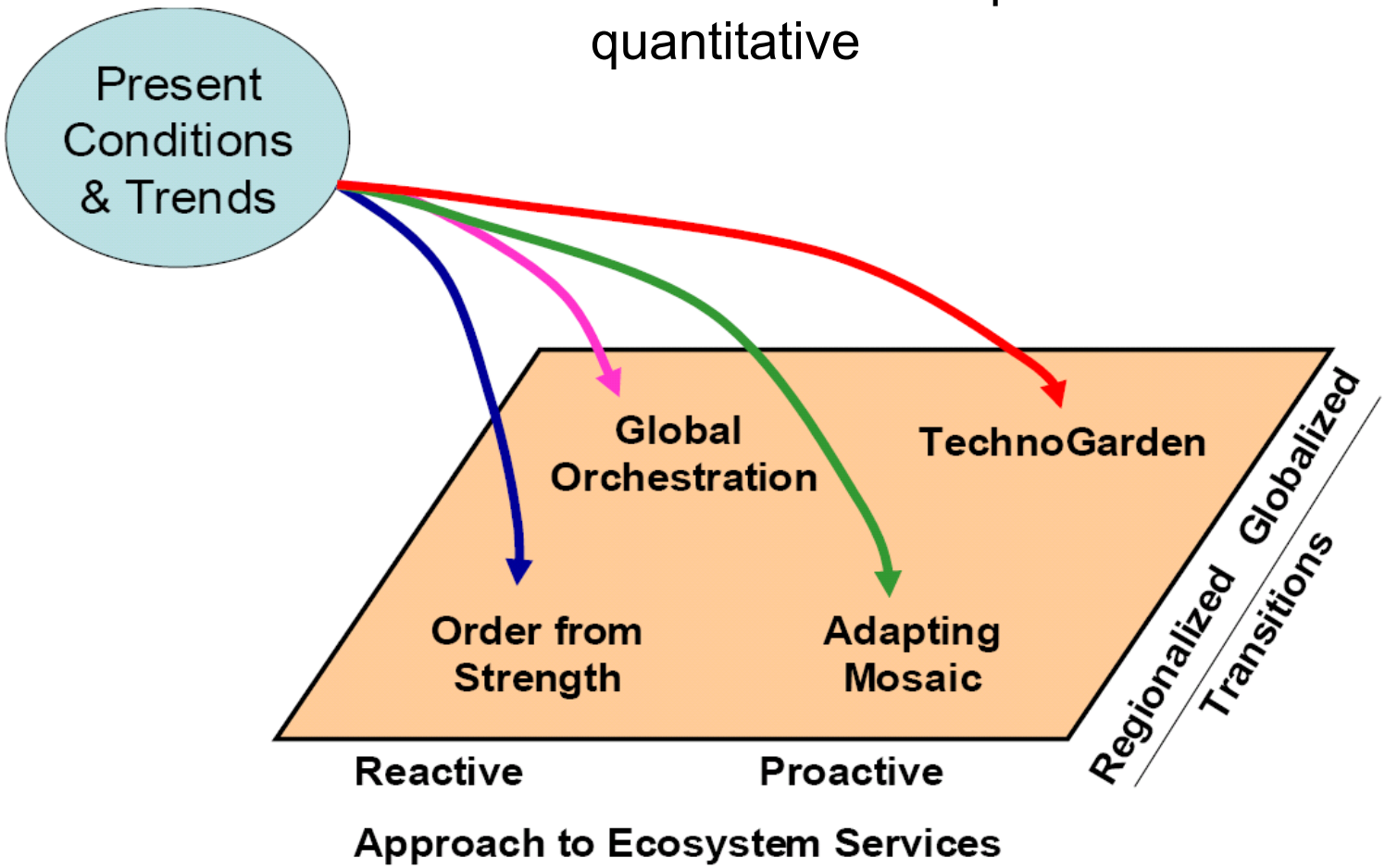
The MA Global Scenario Analysis:
4 Scenarios

- Not predictions – scenarios are plausible futures
- Scenarios: both qualitative and quantitative



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The MA Global Scenario Analysis: **Qualitative: Scenario Storylines**

- **Global Orchestration** Globally connected society; intensified global trade and economic liberalization; invests in public goods (infrastructure & education); reactive approach to ecosystem problems;

- **Order from Strength** Regionalized and fragmented world; concerned with security and protection; regional markets; little attention to public goods, reactive approach to ecosystem problems.

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The MA Global Scenario Analysis: **Qualitative: Scenario Storylines**

- **Adapting Mosaic** Regional watershed-scale ecosystems are focus of political and economic activity; local ecosystem management strategies are common; strongly proactive approach to management of ecosystems.

- **TechnoGarden** Globally connected world relying strongly on environmentally sound technology; proactive approach to the management of ecosystems – managed, often engineered, ecosystems.

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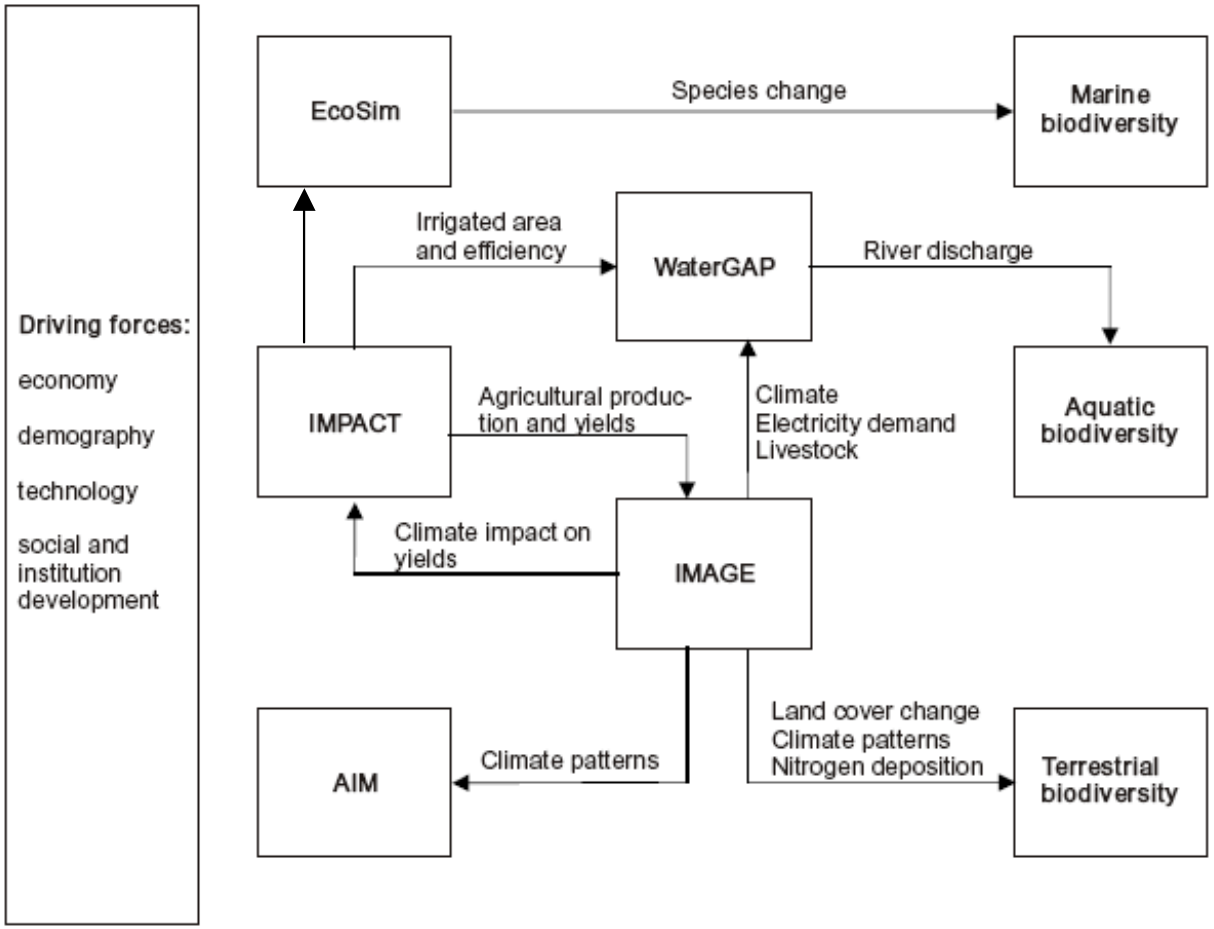
The MA Global Scenario Analysis: **Quantitative: The Global Modeling Exercise**



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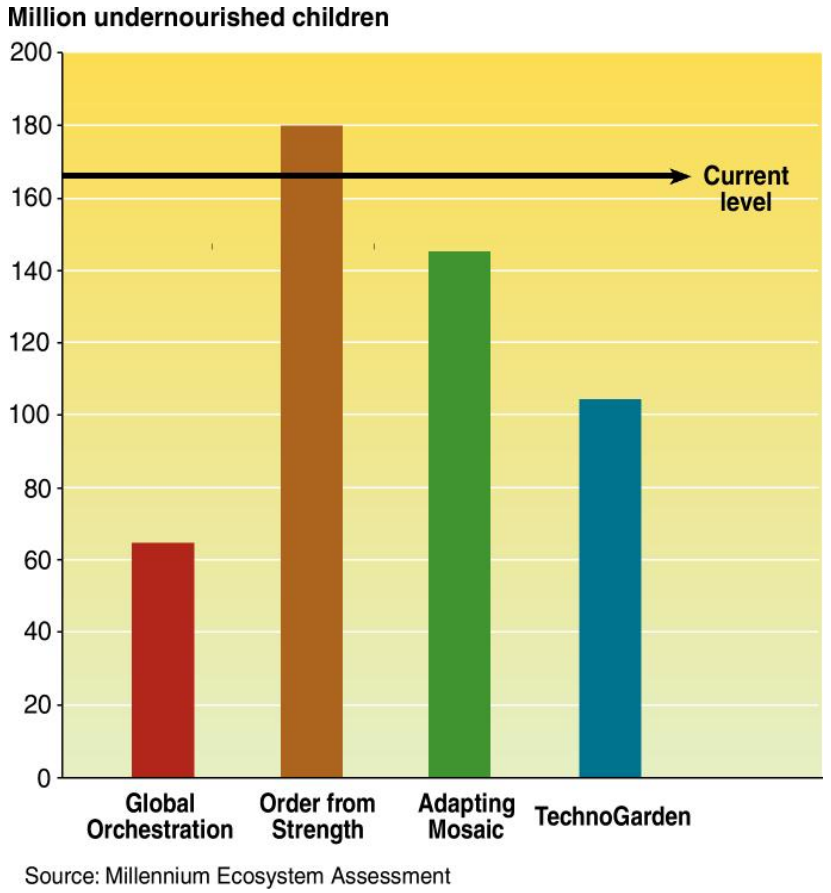
Gains in ecosystem services: **Food production**

By 2050:

Food production increases by 70–85%.

Child malnutrition decreases under 3 of 4 scenarios.



Source: Millennium Ecosystem Assessment

Child undernourishment in 2050 under MA Scenarios

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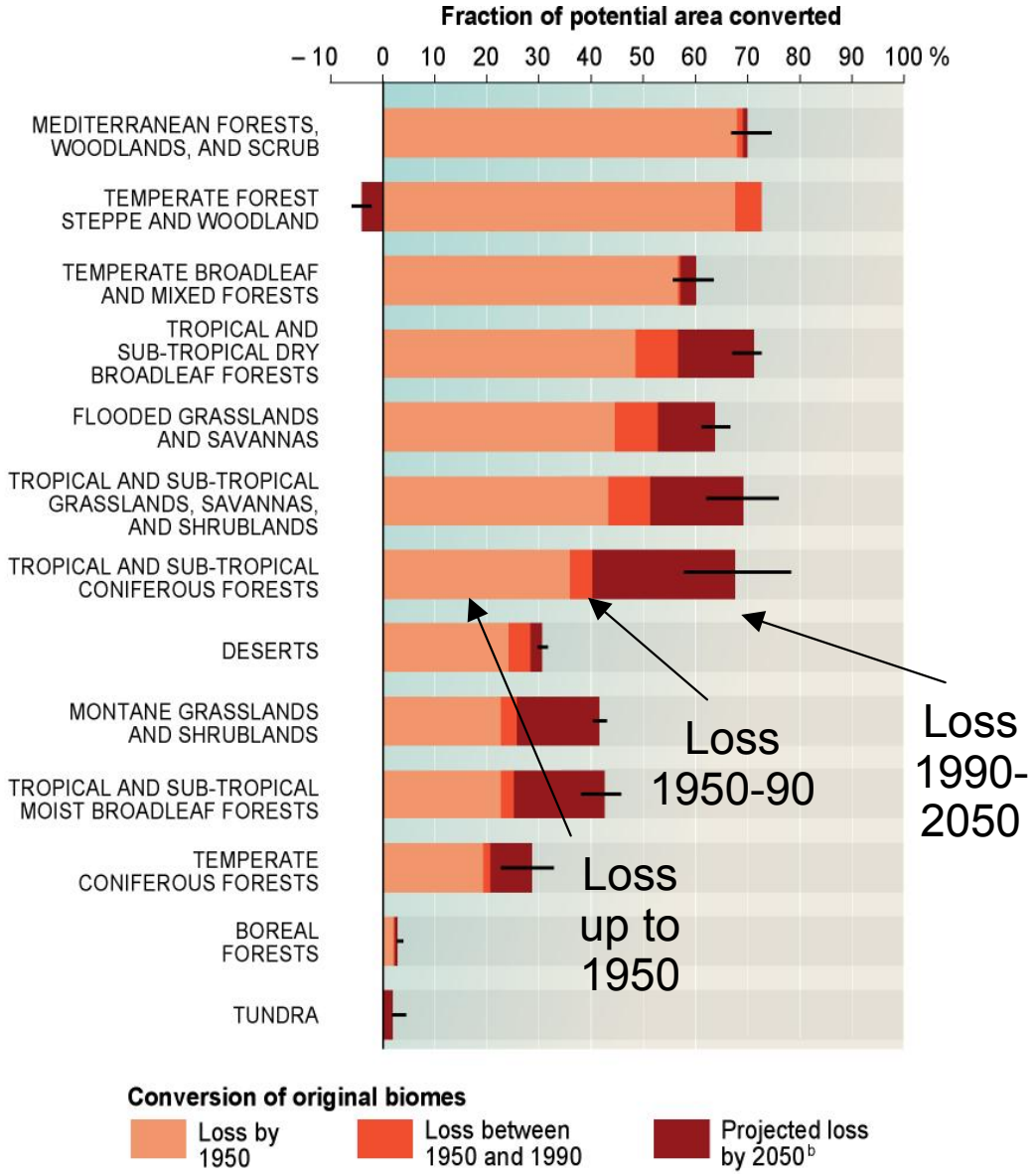
Intensified tradeoffs between ecosystem services
Agriculture land expands over grasslands and forests

By 2050:

Expansion of agricultural land main cause of 10–20% loss of natural grassland and forests

Loss of services associated with grassland and forests (wood products, medicine, climate regulation)



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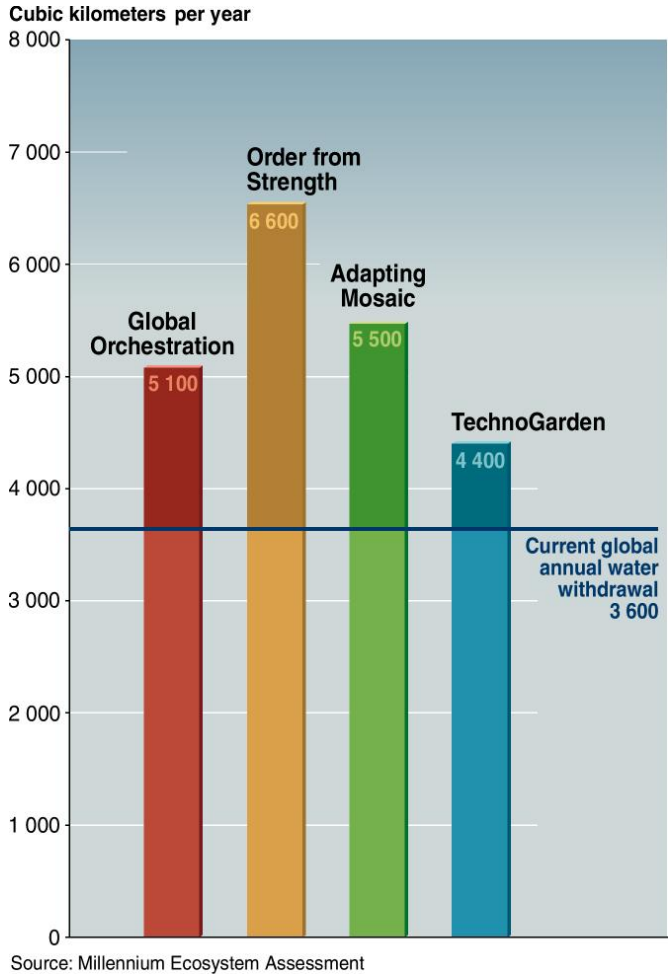
Gains in ecosystem services:
Freshwater services

By 2050:

Global water availability increases by 5 –7%

Water withdrawals increase 30% - 85%



Water Withdrawals in 2050 under MA Scenarios

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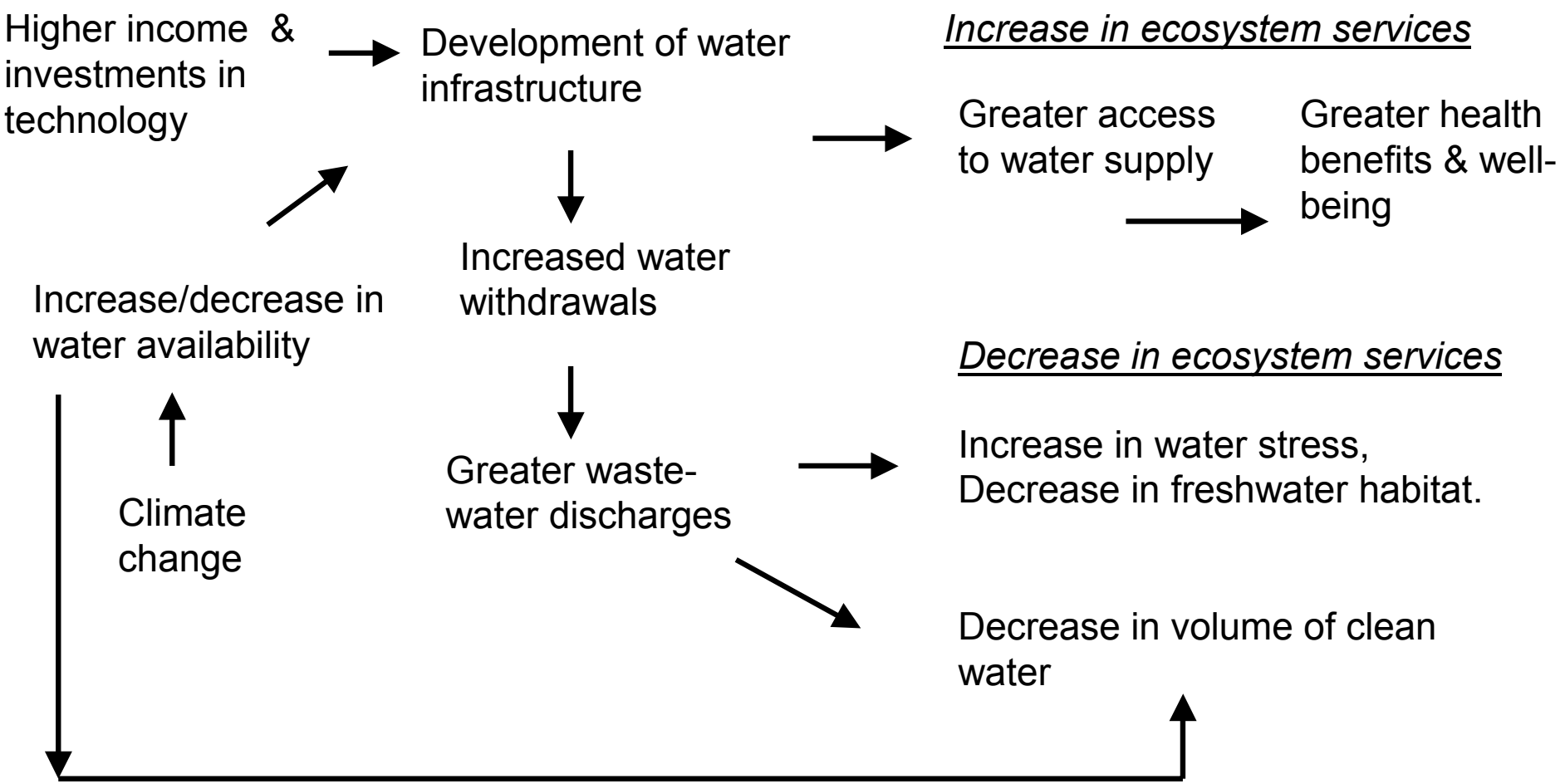
Intensified tradeoffs between ecosystem services
Freshwater



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Increased likelihood of nonlinear changes

Changes being made in ecosystems are increasing the likelihood of *nonlinear* changes in ecosystems (accelerating, abrupt, and potentially irreversible changes)  important consequences for human well-being.

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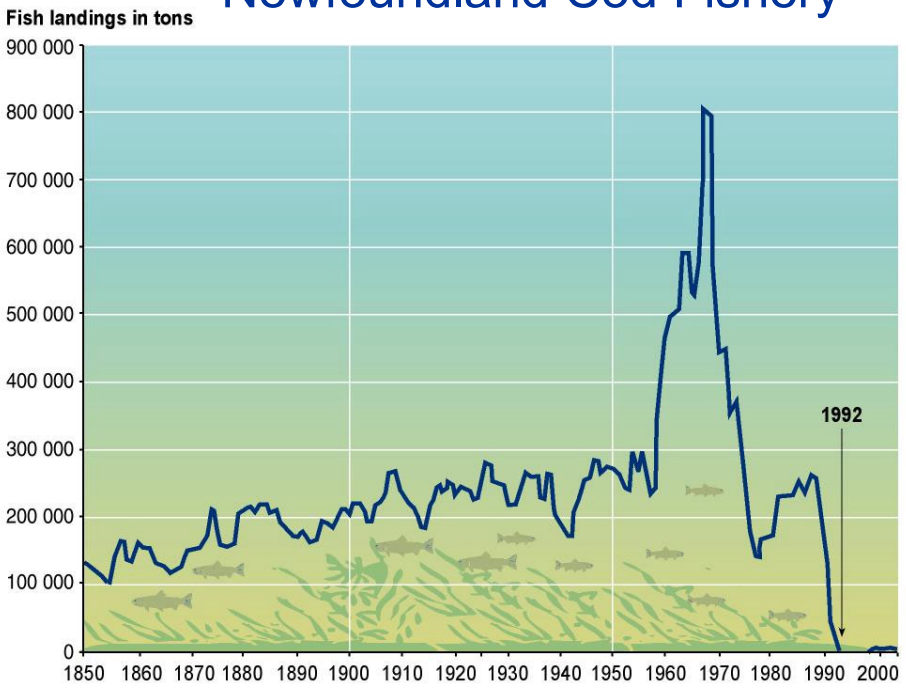
Example of nonlinear change

Fisheries collapse
1992: Collapse of Atlantic cod fishery off coast of Newfoundland

Invasive alien species
Introduction of zebra mussels into North American aquatic ecosystems caused $100 million damage to power industry, other users

Rapid regional climate change
Desertification causes decline in regional precipitation (Africa, Latin America) 🎭 further changes in forest cover

Newfoundland Cod Fishery



Source: Millennium Ecosystem Assessment

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Factors causing increase in likelihood of nonlinear changes

- Loss of species and genetic diversity → decreases resilience of ecosystems
- Growing pressures from drivers: over-harvesting, climate change, invasive species, and nutrient loading → push ecosystems toward thresholds that they might otherwise not encounter

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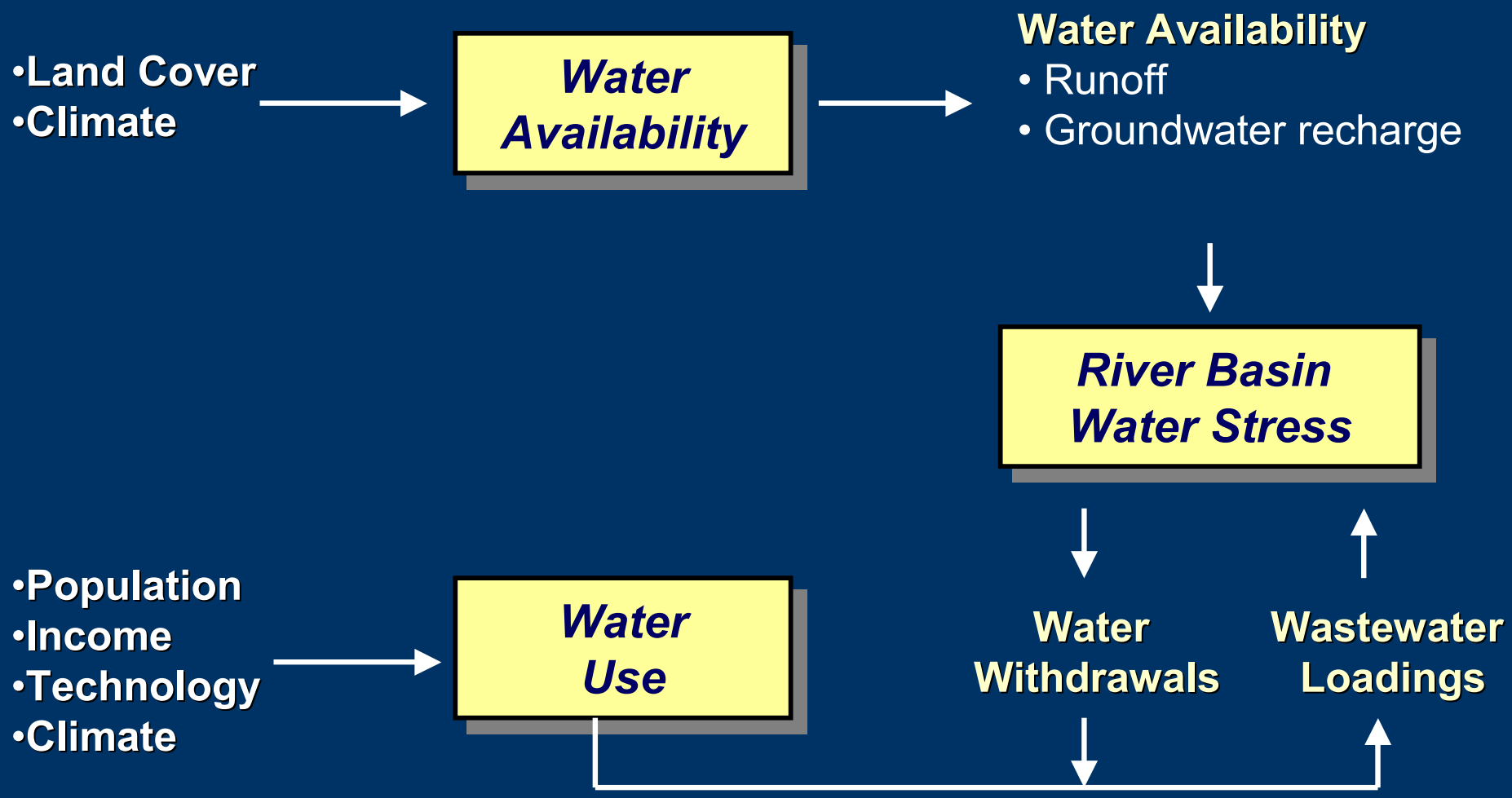
MA Global Scenario Analysis:
Main findings

- Ecosystem services will increase but their reliability is unclear
- Tradeoffs between services will intensify
- Likelihood of abrupt changes in world ecosystems is increasing

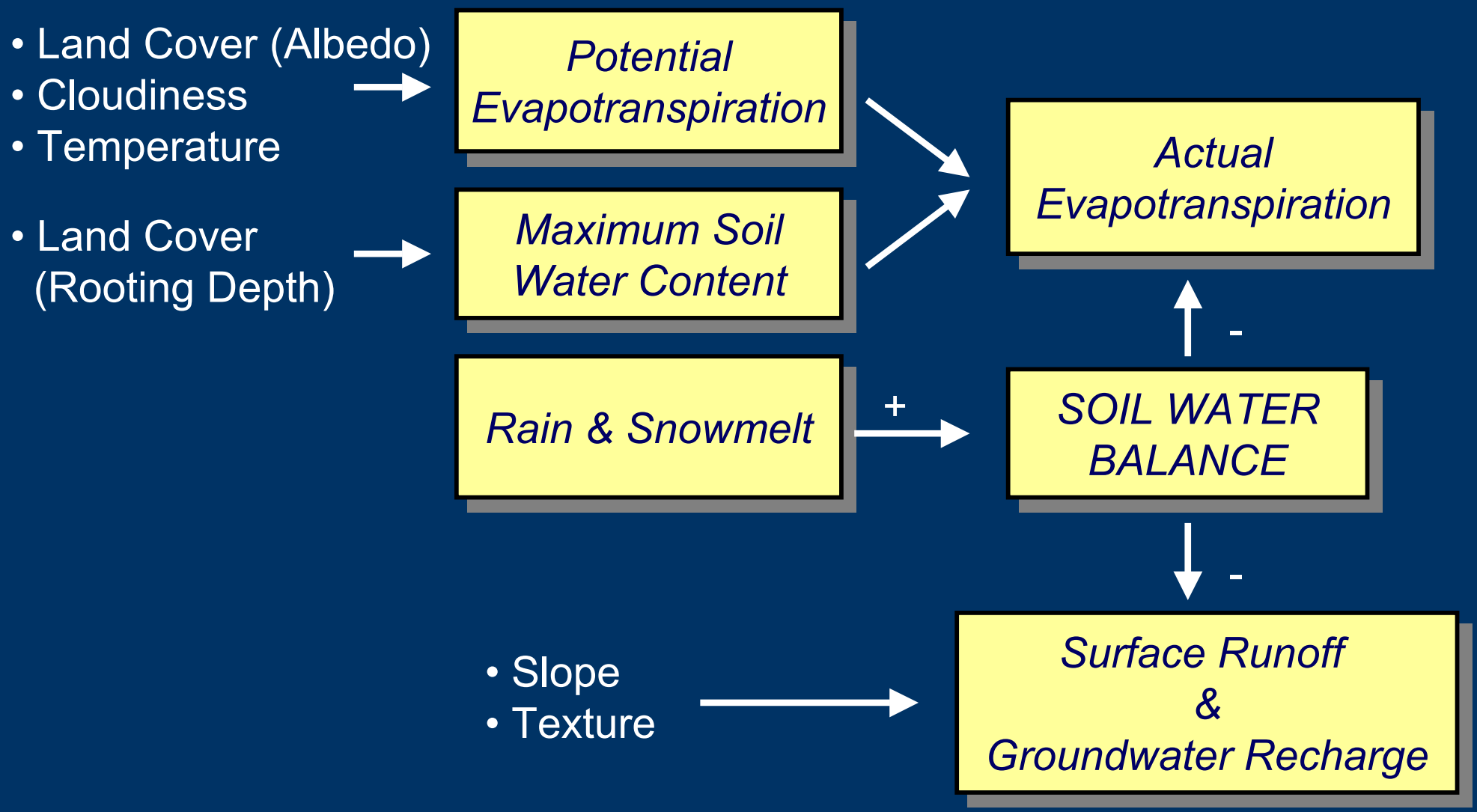
Part B The WaterGAP model:

Global modeling for global assessments

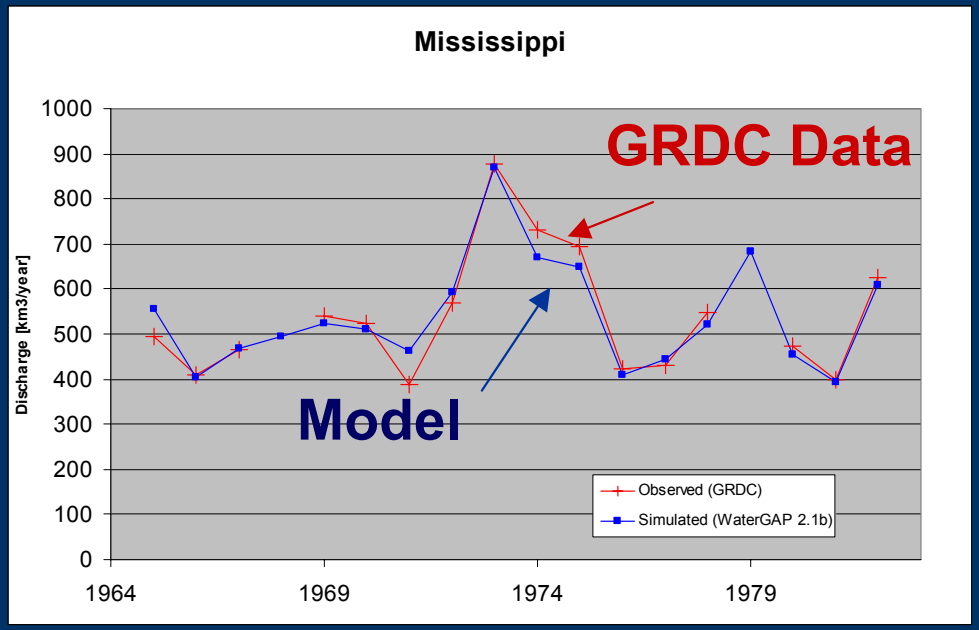
WaterGAP 2 Model
- Overview -

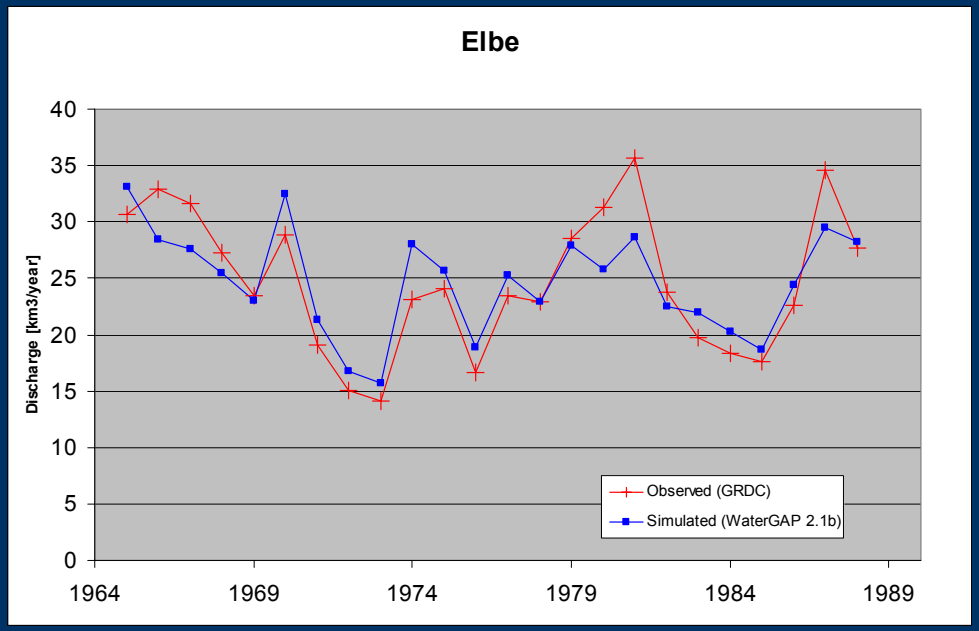


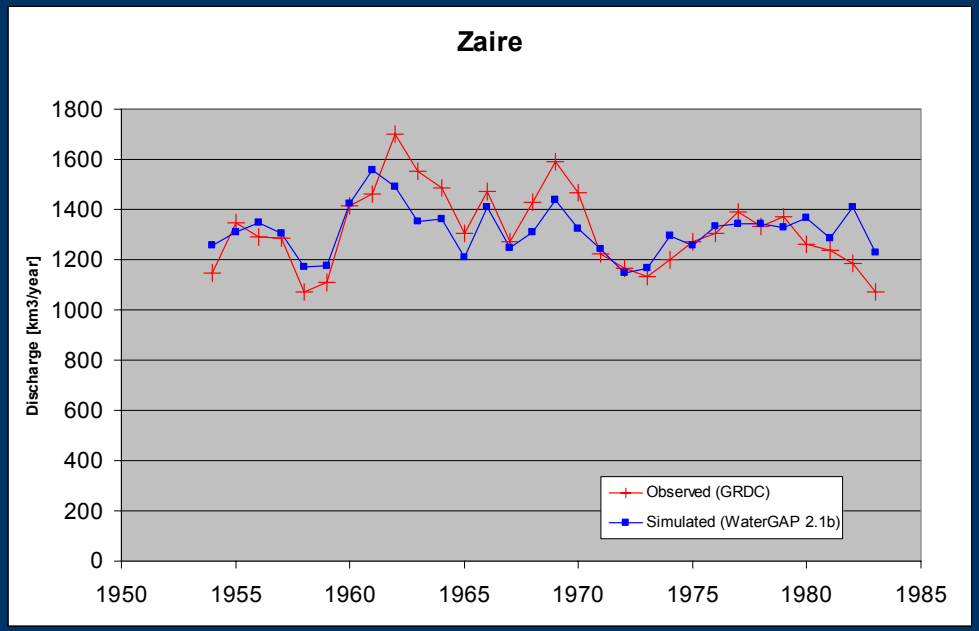
WaterGAP 2
- Global Hydrologic Model -

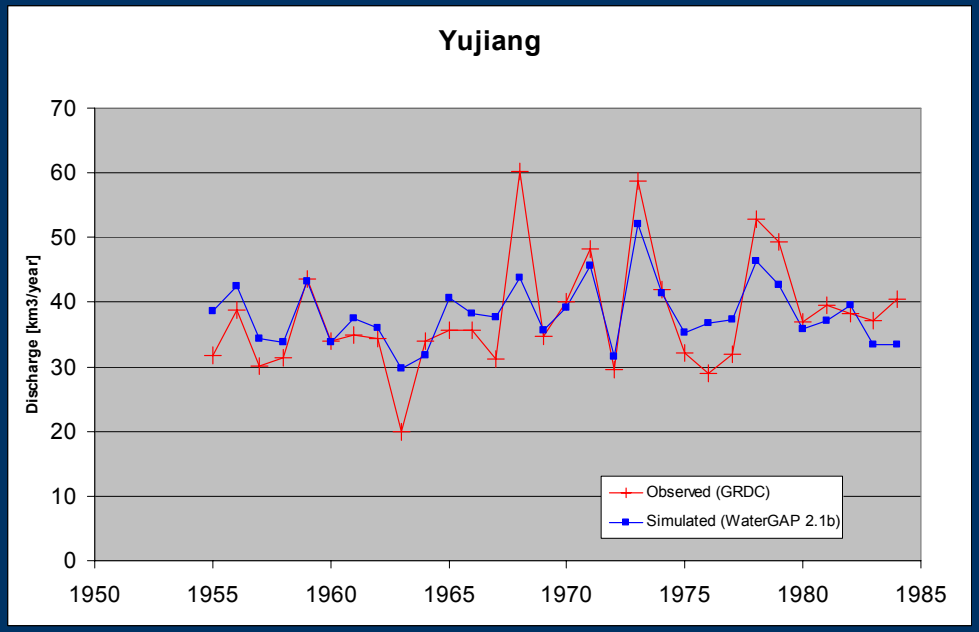


Testing the Global Hydrologic Model



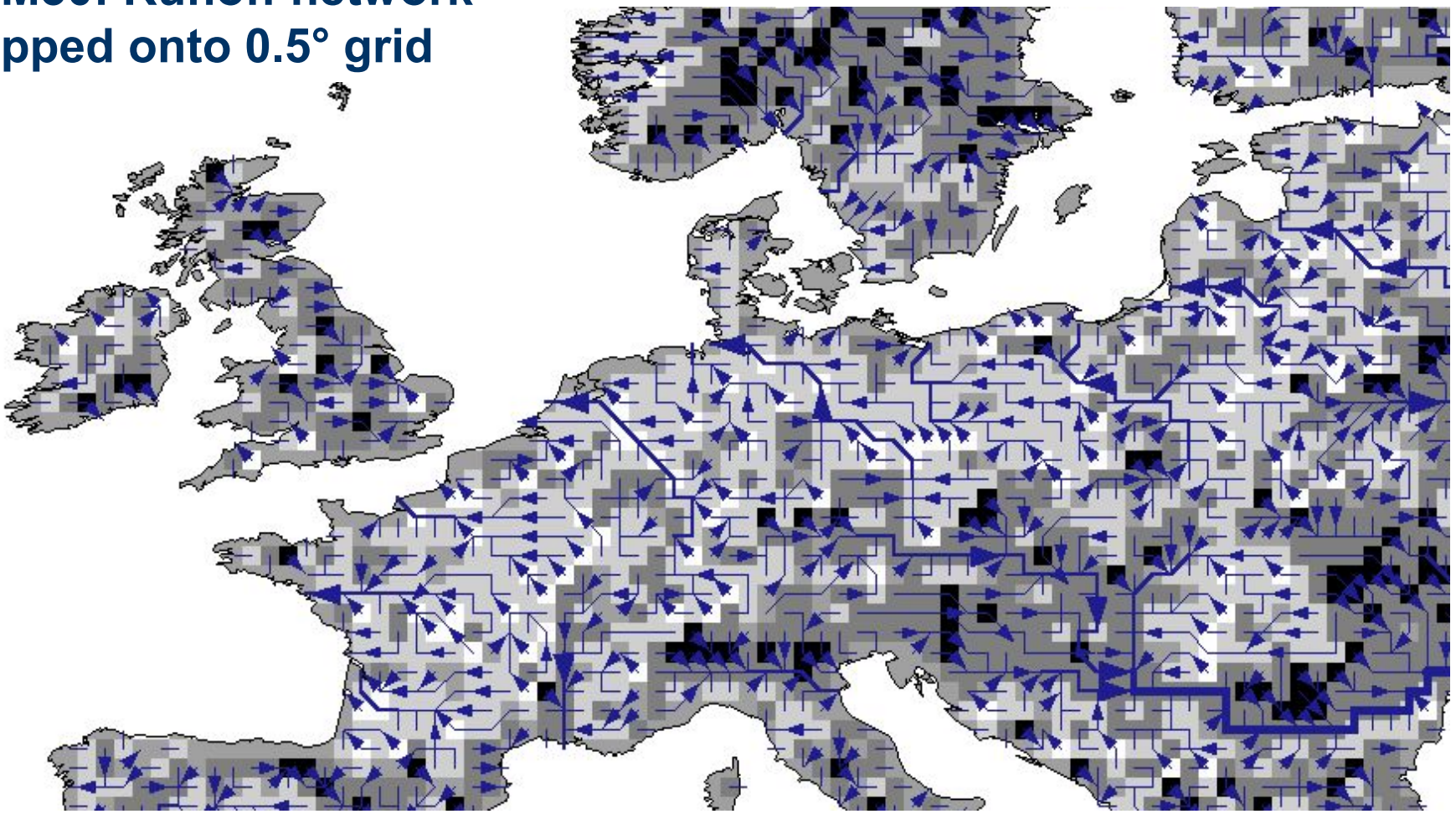






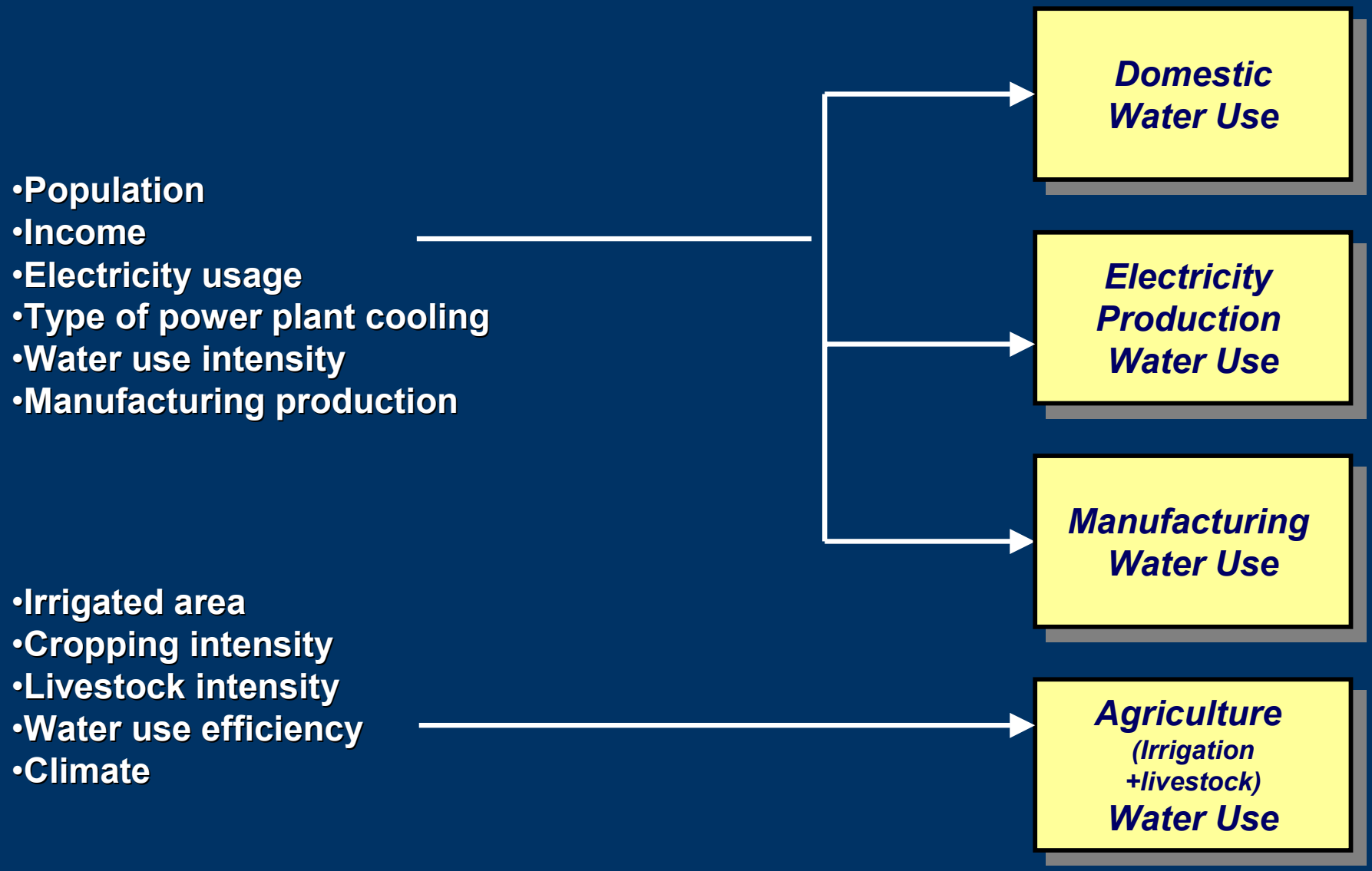
Data Requirements: e.g. Drainage Direction

DDM30: Runoff network mapped onto 0.5° grid

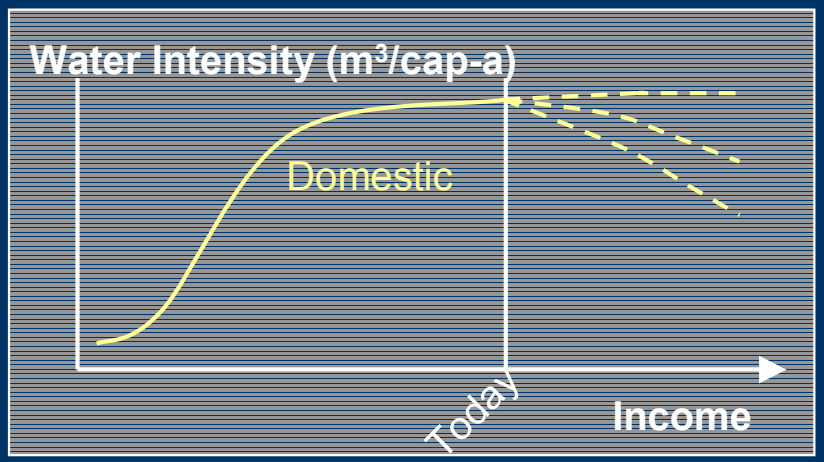


Quelle: WaterGAP, 2000

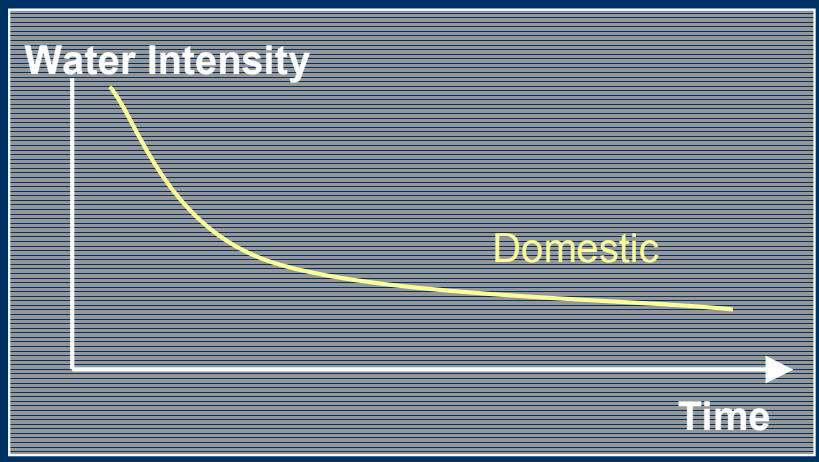
WaterGAP 2
- Water Use Model -



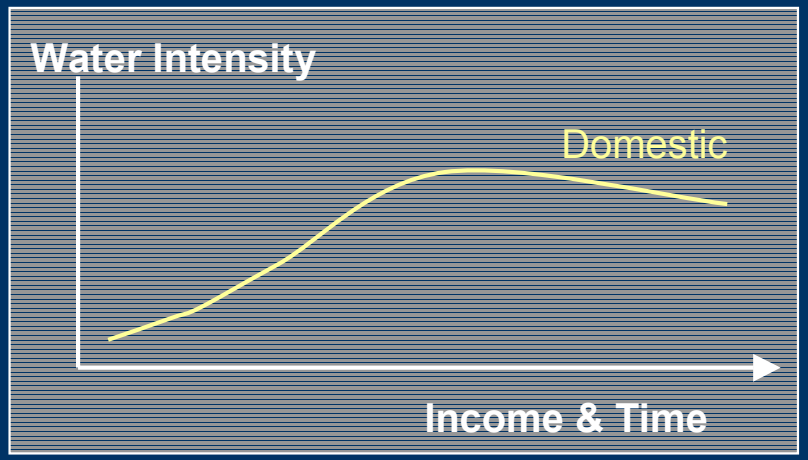
WaterGAP 2
- Water Use Model : Domestic Sector -



Structural Change
(changing behaviour and infrastructure)

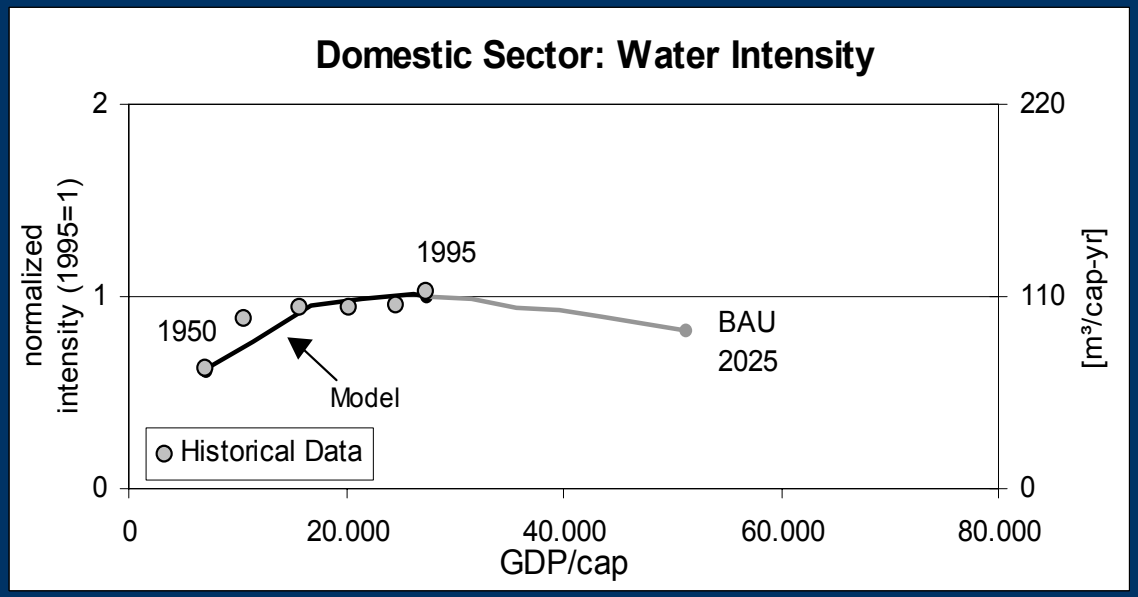


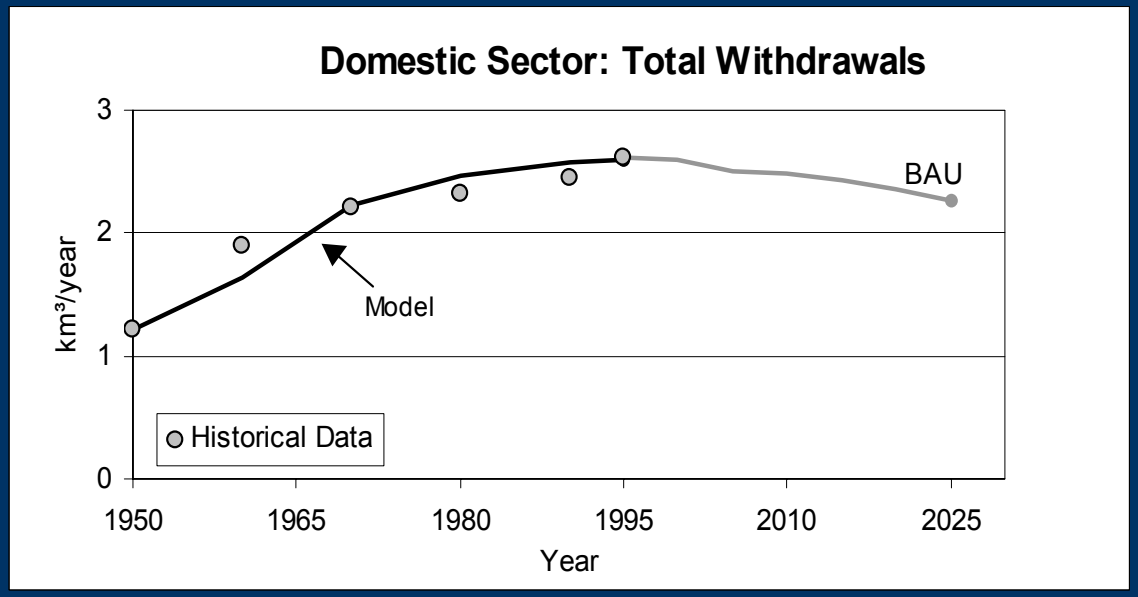
Technological Change
(improving water use efficiency)



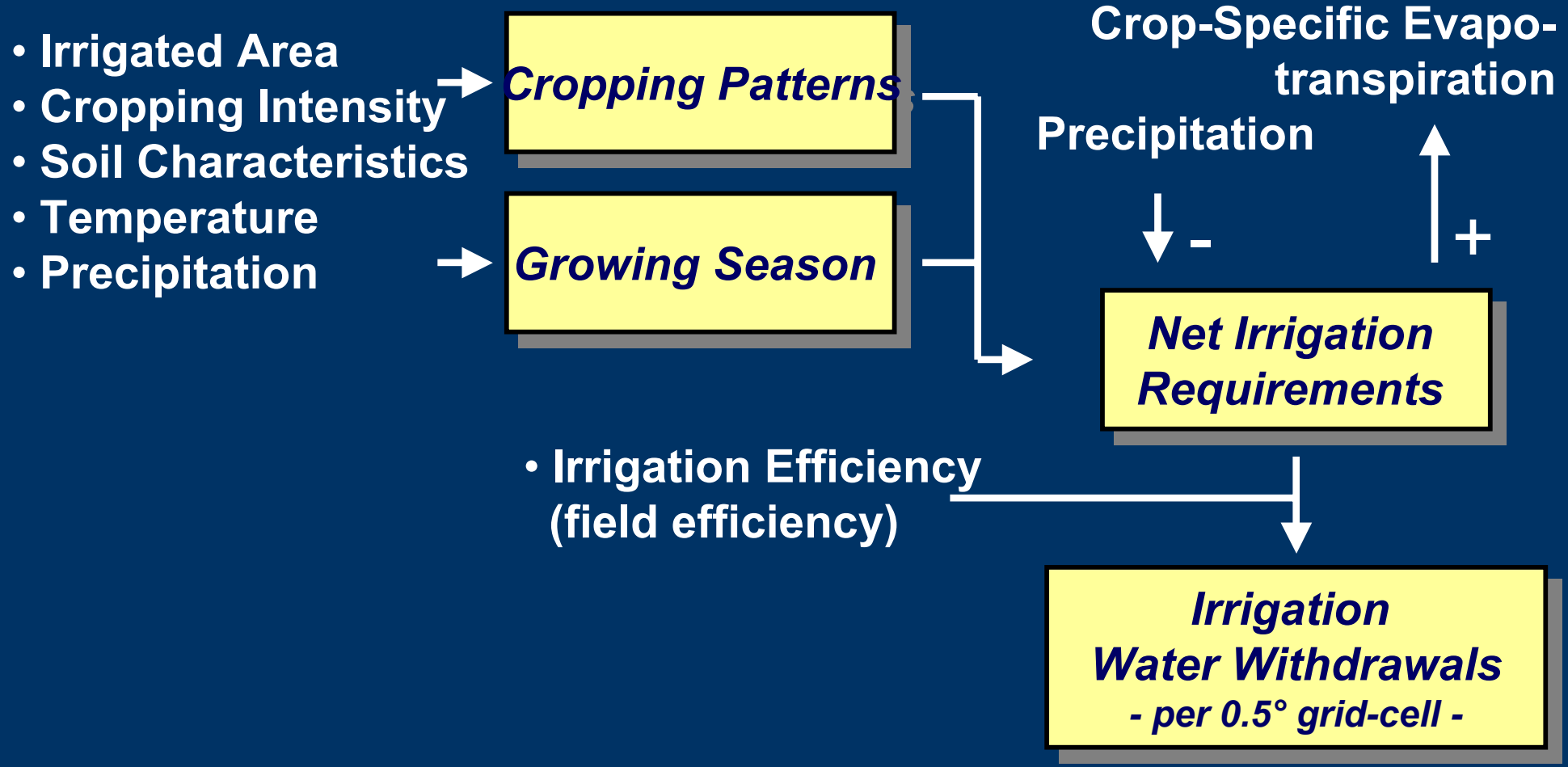
Structural & Technological Change

Domestic Sector
Northern Europe

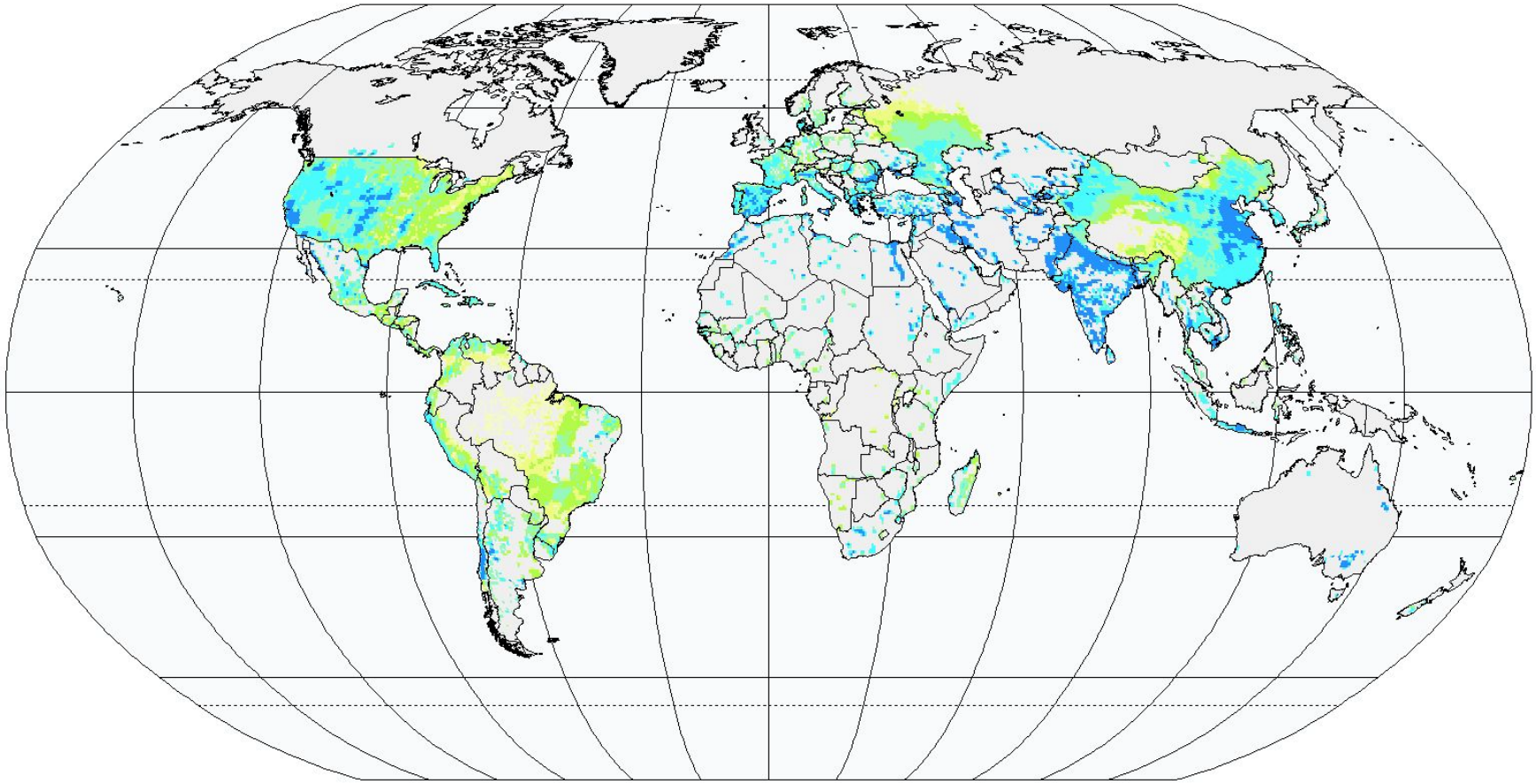




WaterGAP 2
- Water Withdrawals Model : Irrigation -



Water Use for Irrigation (mm/a)



Map 8. Water withdrawals for irrigation on a global grid, circa 1995 [mm/a]

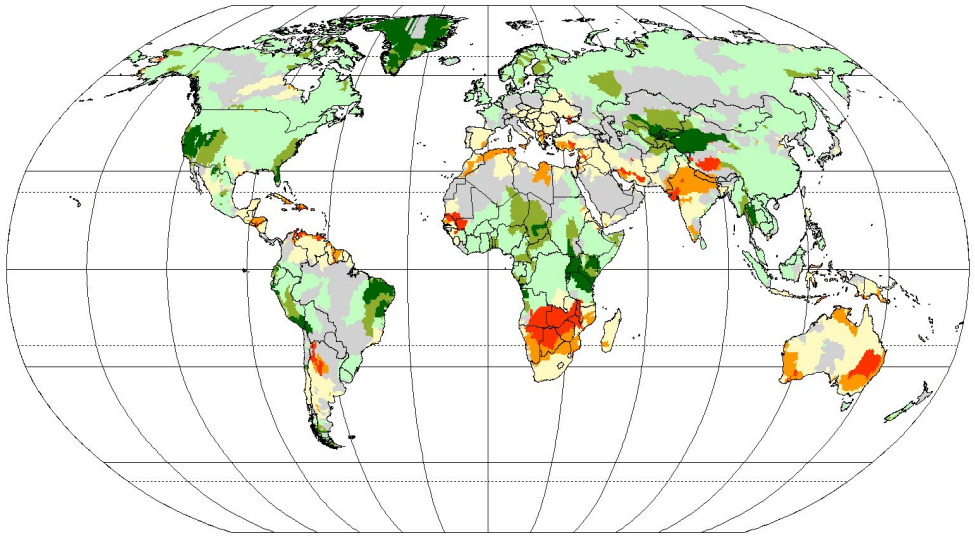
Doell & Siebert 2002

0 | 0.01 | 0.1 | 1 | 10 | 100 [max 2290]

no water withdrawals for irrigation

What are the WaterGAP results for the Millennium Ecosystem Assessment?

Change in annual water availability
(Global Orchestration 2050)

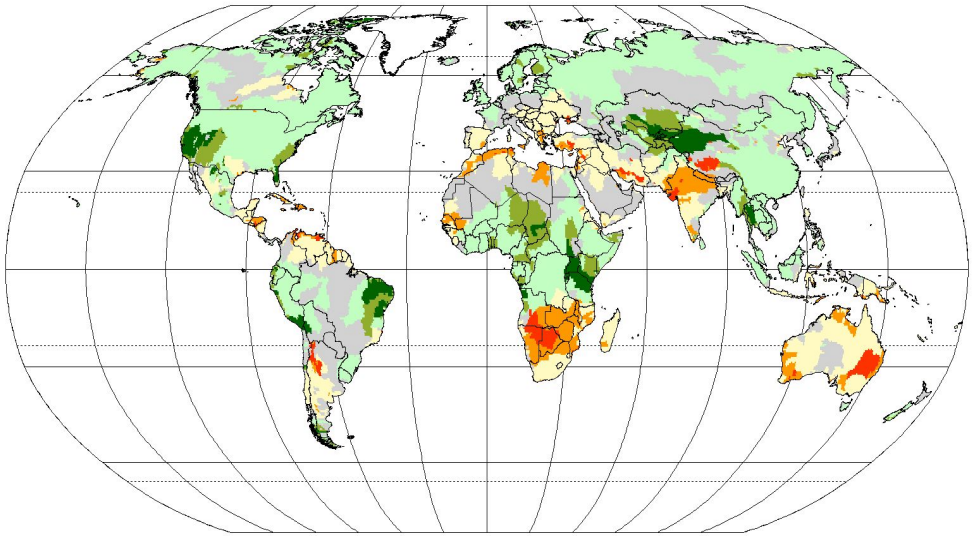


Percentage change

-50 -25 -5 5 25 50

no data

Change in annual water availability
(Techno Garden 2050)

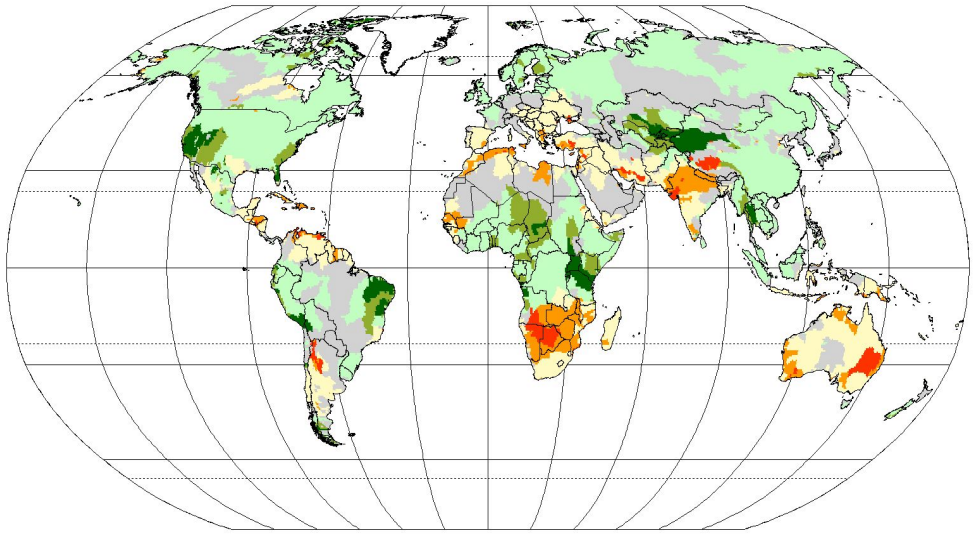


Percentage change

-50 -25 -5 5 25 50

no data

Change in annual water availability
(Adapting Mosaic 2050)

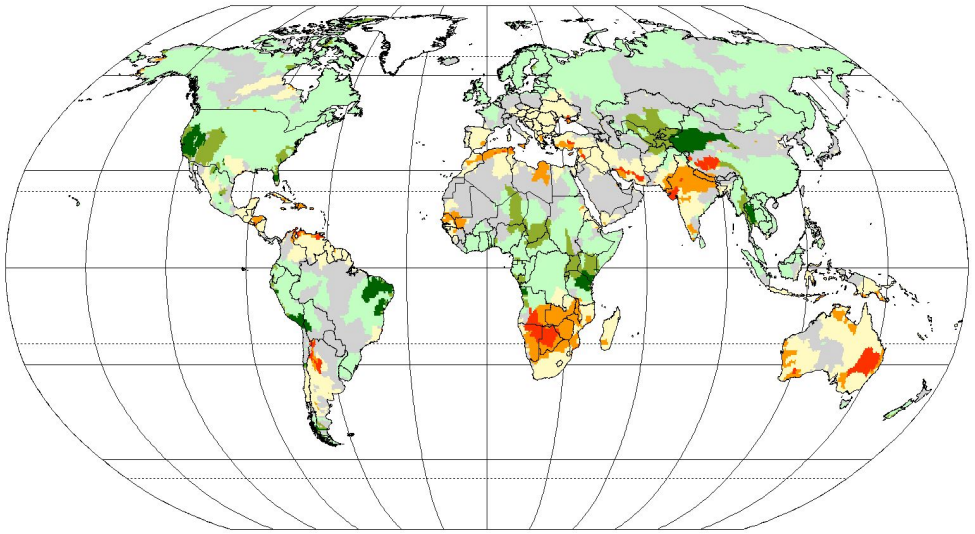


Percentage change

-50 -25 -5 5 25 50

no data

Change in annual water availability
(Order from Strength 2050)

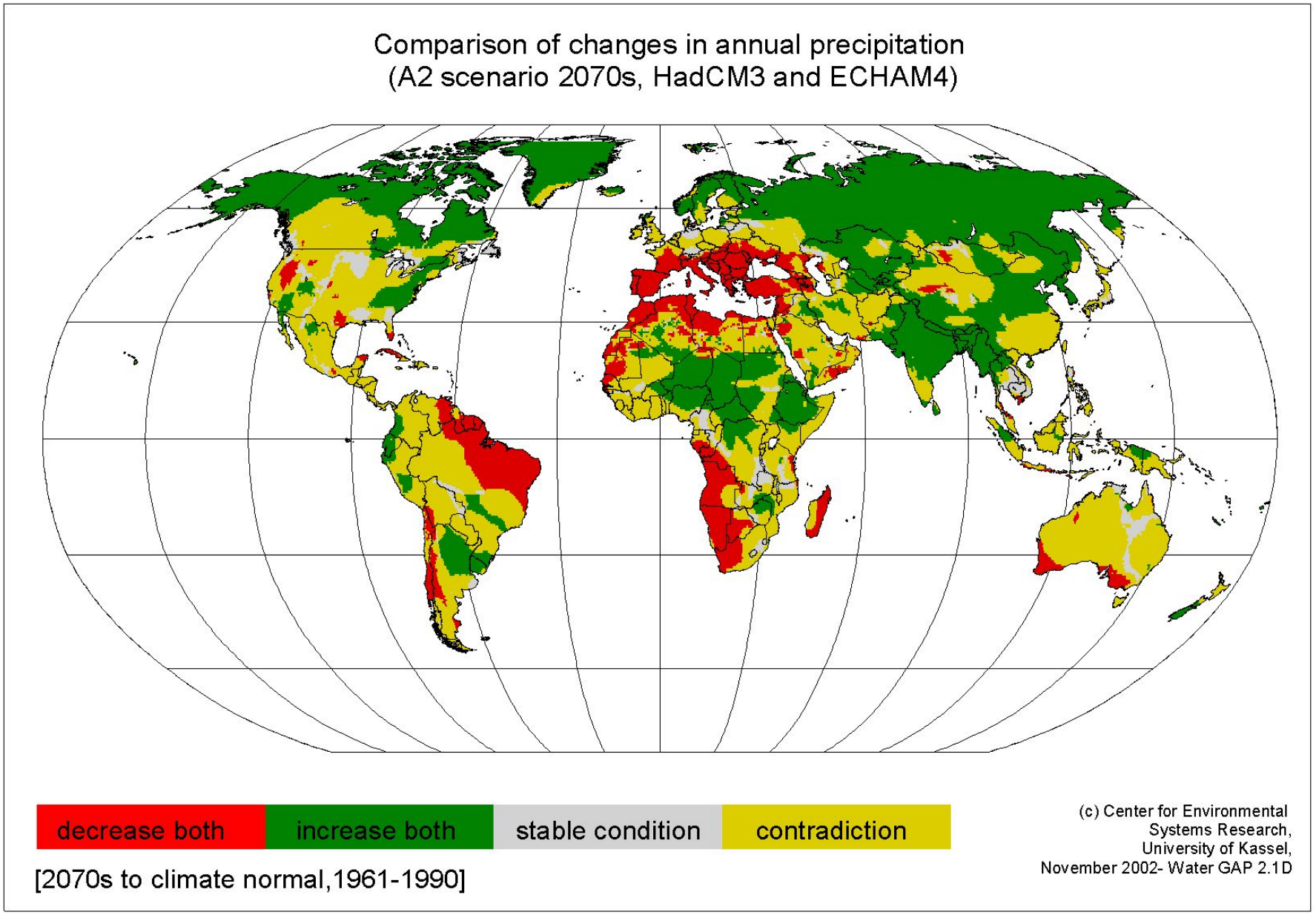


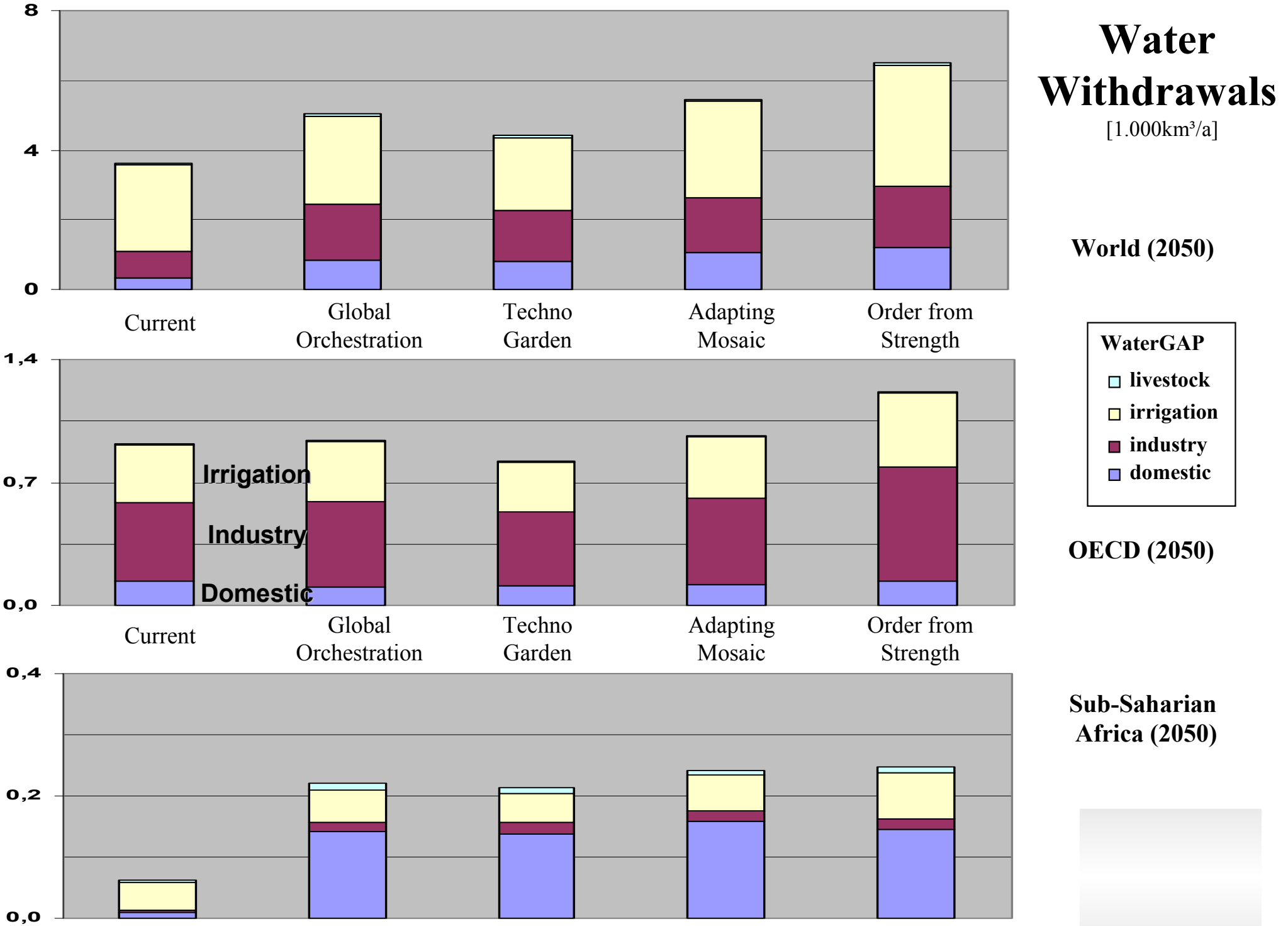
Percentage change

-50 -25 -5 5 25 50

no data

Uncertainty of Precipitation Estimates (2070s : GCM Comparison, A2)



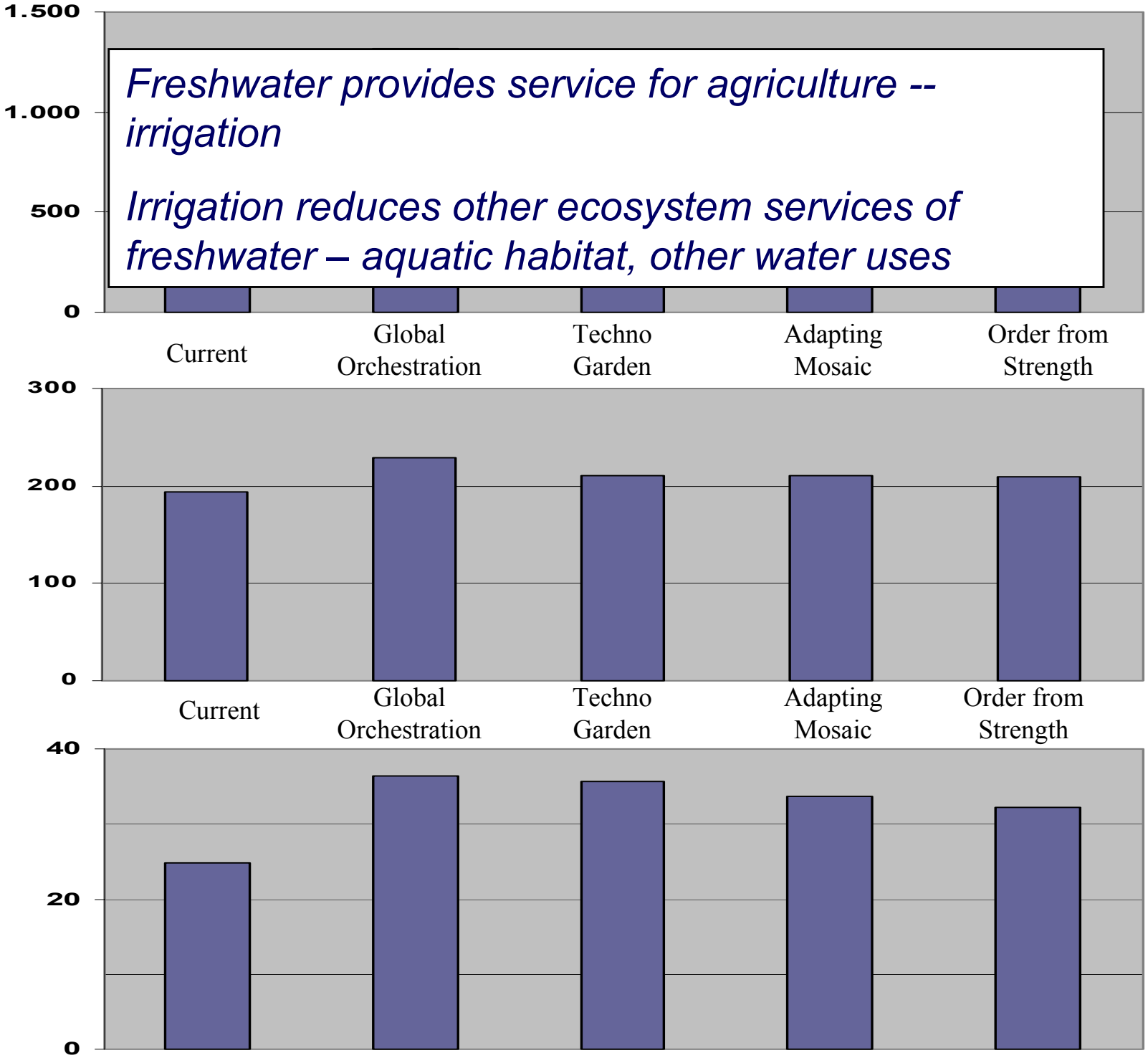

Water Withdrawals
[1.000km³/a]
World (2050)
OECD (2050)
Sub-Saharian Africa (2050)
WaterGAP
livestock
irrigation
industry
domestic
8
4
0
1,4
0,7
0,0
0,4
0,2
0,0
Irrigation
Industry
Domestic
Current
Global Orchestration
Techno Garden
Adapting Mosaic
Order from Strength

Consumptive Irrigation Water Use

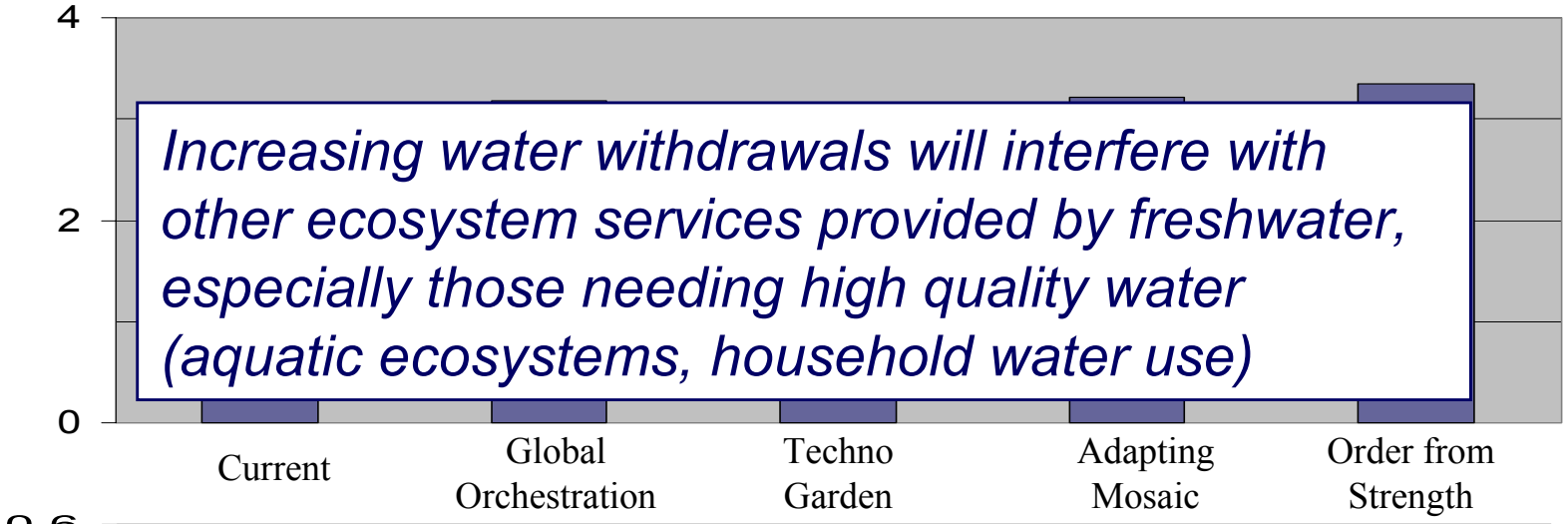
[km3/a]

Freshwater provides service for agriculture -- irrigation

Irrigation reduces other ecosystem services of freshwater – aquatic habitat, other water uses



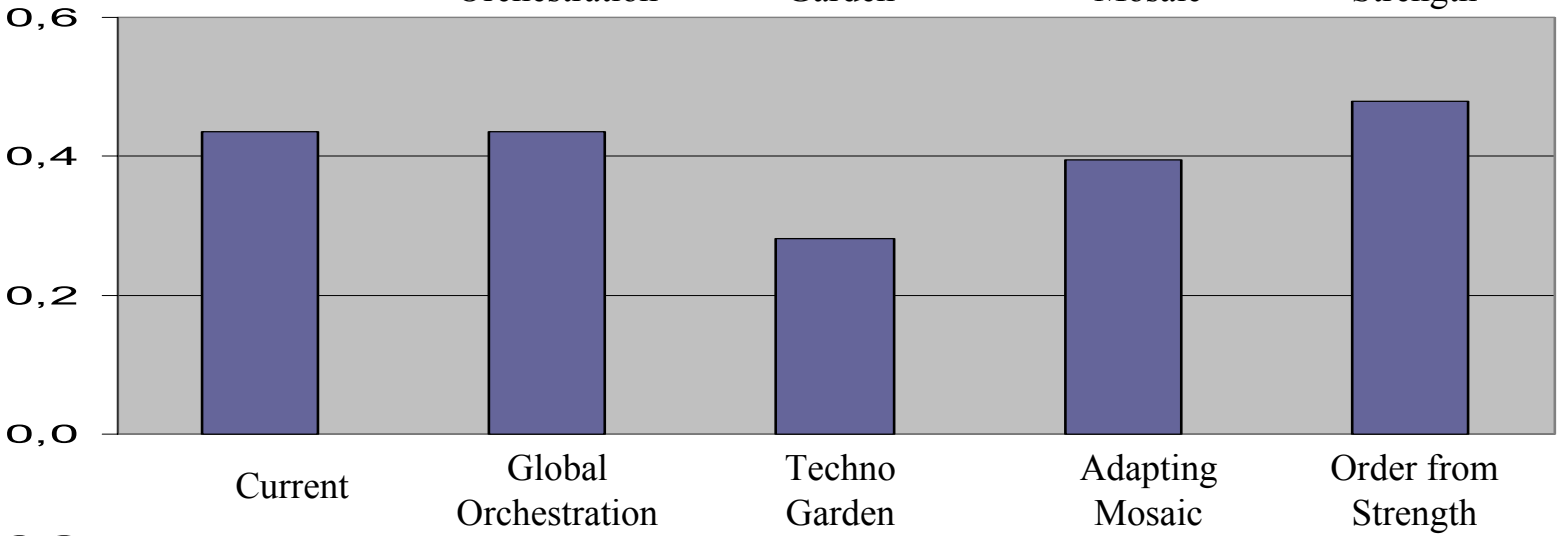
Increasing water withdrawals will interfere with other ecosystem services provided by freshwater, especially those needing high quality water (aquatic ecosystems, household water use)



Polluted Water volume

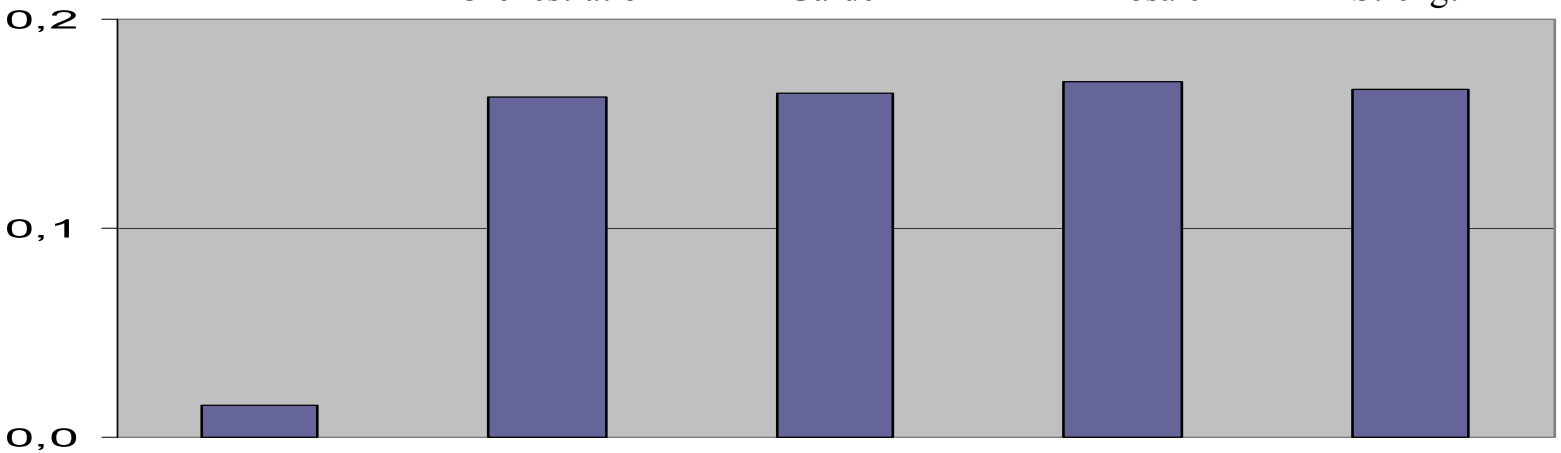
[1.000km³/a]

World (2050)



WaterGAP

OECD (2050)



Sub-Saharian Africa (2050)

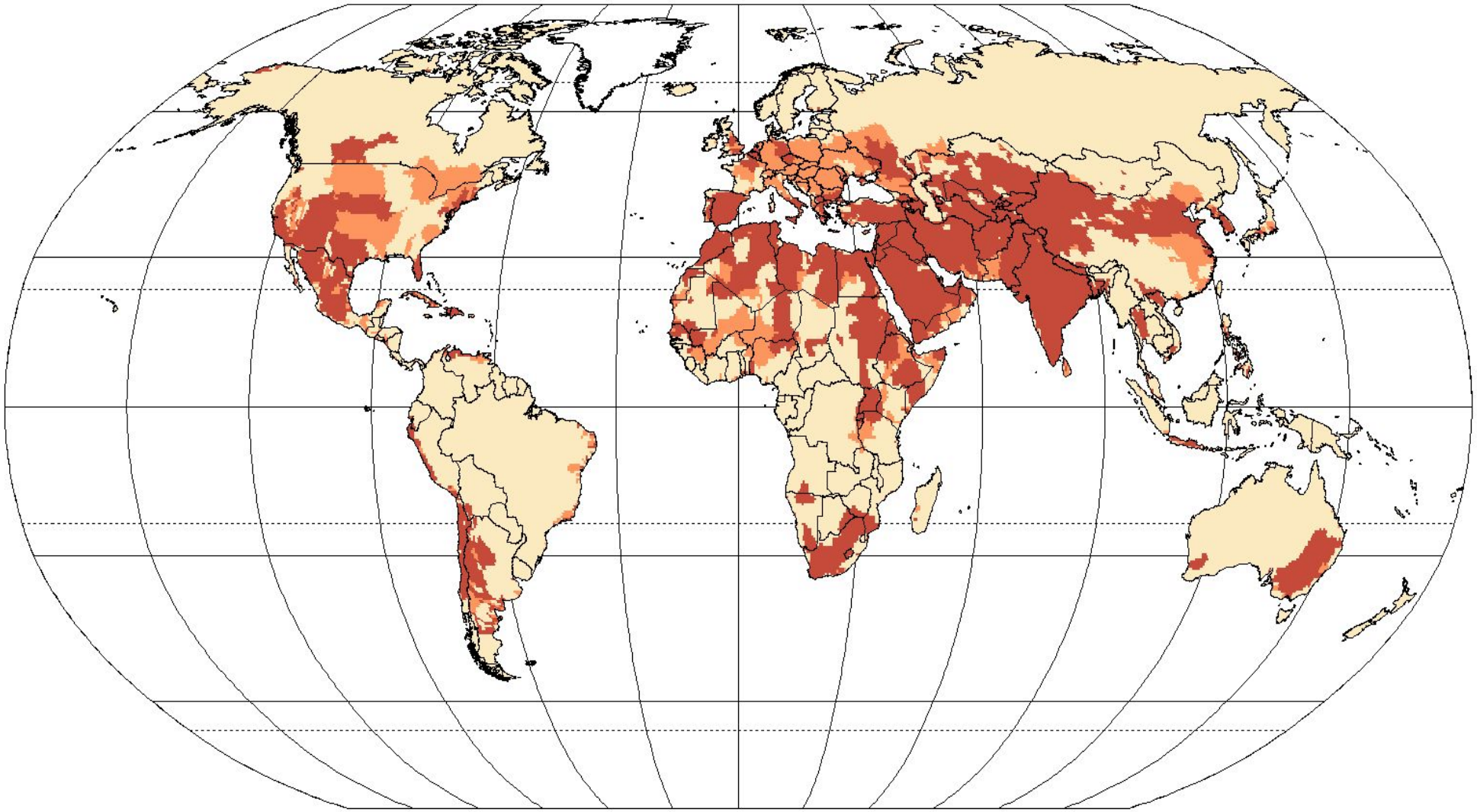
Water Stress Indicator
withdrawals-to-availability ratio

For each River basin

$$wta = \frac{\text{Annual Withdrawals}}{\text{Annual Availability}}$$

Common guideline for severe water stress : wta > 0.4

Withdrawal to availability ratio
(Order From Strength 2050)



0 - 0.2
[low water stress]

0.2 - 0.4
[mid water stress]

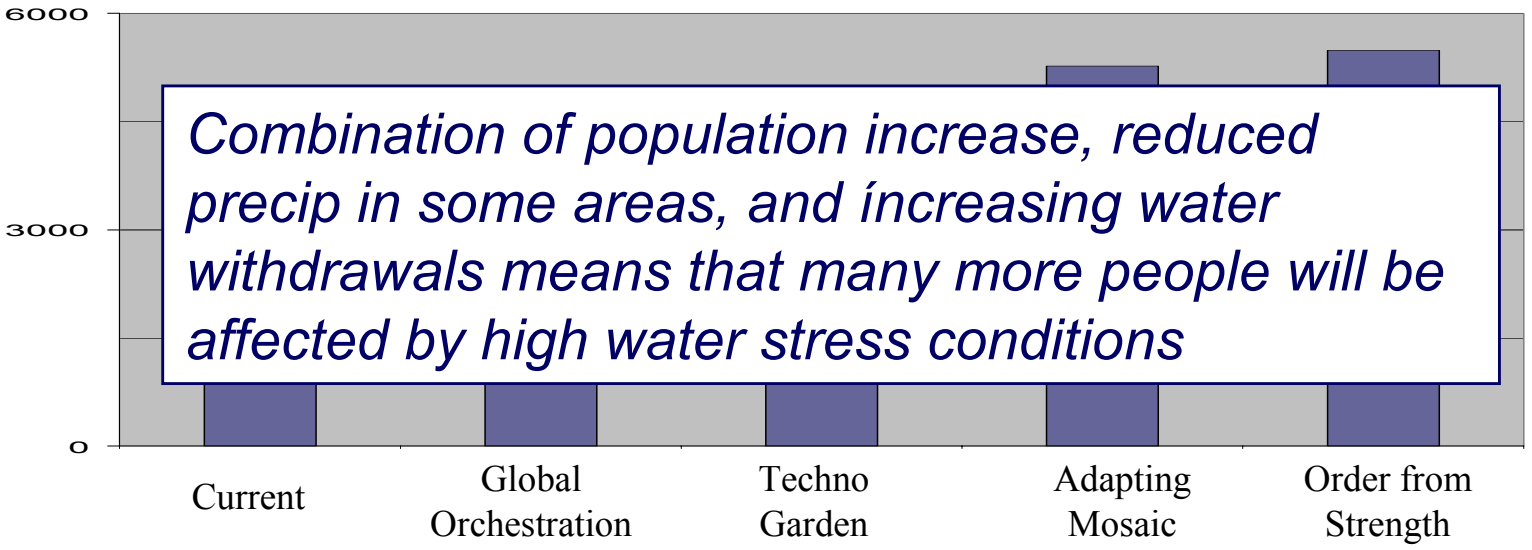
more than 0.4
[severe water stress]

no data

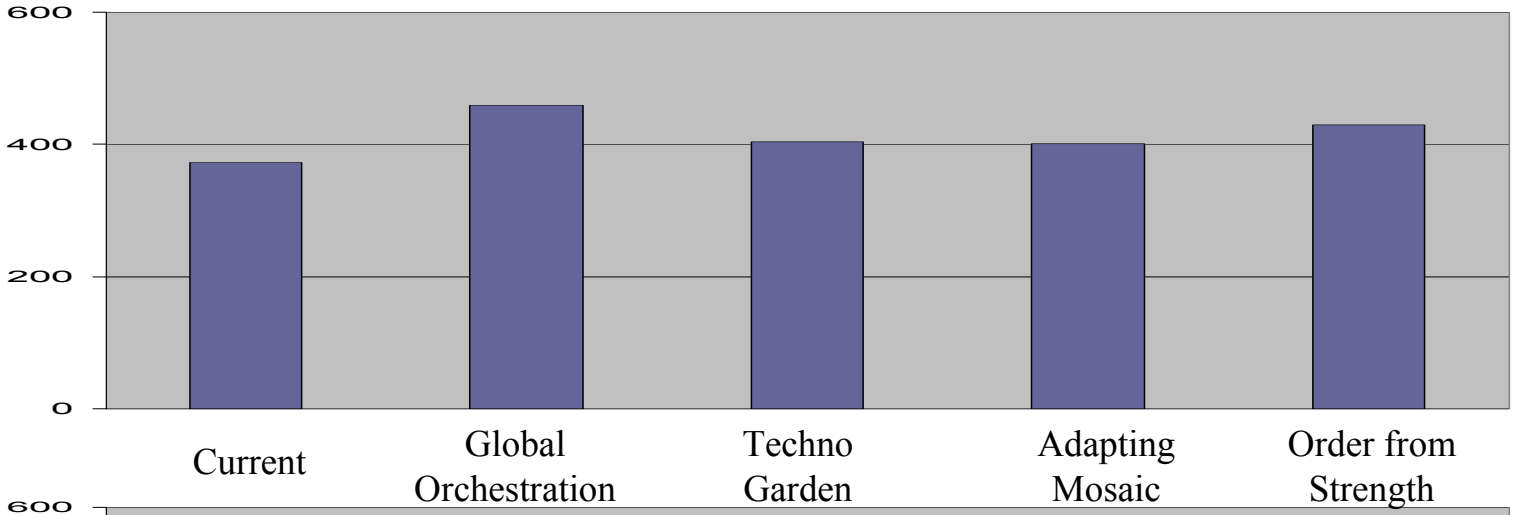
Population affected by high water stress (wta > 0.4)

[million people]

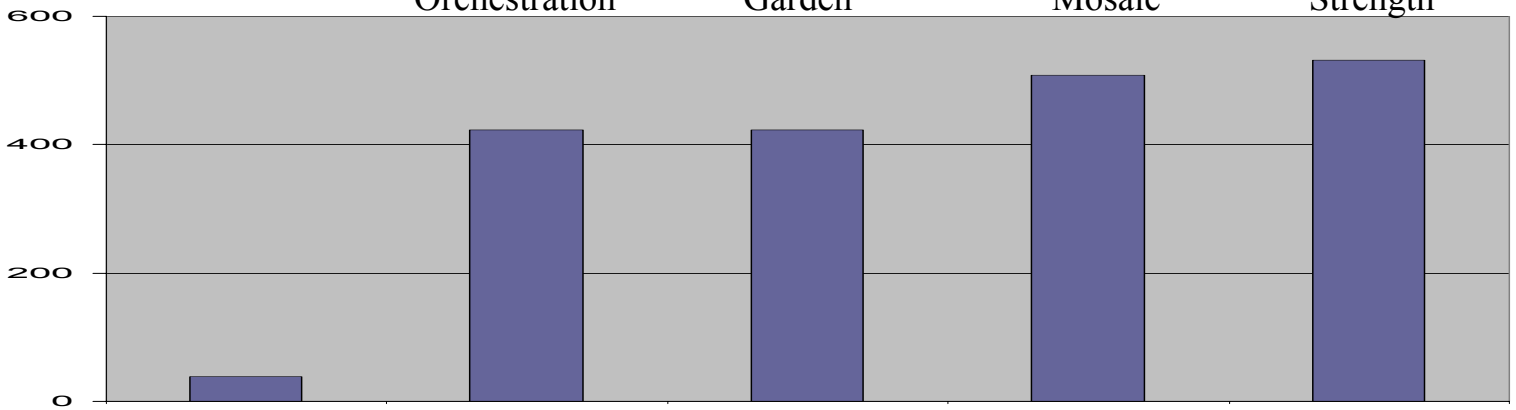
Combination of population increase, reduced precip in some areas, and íncreasing water withdrawals means that many more people will be affected by high water stress conditions



World (2050)



OECD (2050)



Sub-Saharian Africa (2050)

WaterGAP

Conclusions of WaterGAP Analysis of Freshwater Ecosystem Services

Freshwater ecosystem services will increase:

Global withdrawals (up to 2050) increase 30 to 70% (irrigation, industry, households)

But tradeoffs of ecosystem services:
Gain in some services causes loss of other services ...

Expansion of irrigated land 🎭 stabilization of food supply
But ...
Water consumed by irrigation increases up to 50% 🎭 less water for other services.

Increased withdrawals 🎭 additional services (municipal water supply, agriculture, manufacturing)
But ...
Volume of „polluted“ water increases worldwide 1.5 to 2.5x (in Africa, 9x) 🎭 reduced fisheries, other habitat

Millennium Ecosystem Assessment

Achievements of the Millennium Ecosystem Assessment

- First comprehensive multi-disciplinary assessment of the state of nature (marine fisheries, water resources, forestry, biodiversity).
- Assessment of not only current status but also the future of ecosystems.
- By linking ecosystem services with human well being, makes a bridge to those who believe environmental protection must be sacrificed for the sake of economic development.

  Environmental protection is consistent with economic development