Water security and climate change

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Overview

- *Research - from impacts to adaptation*
- *The 2000s; divergence and specialisation*
  - *Downscaling*
  - *Characterising uncertainty*
  - *Dealing with uncertainty*
  - *Contextual approaches*
  - *Integrated assessments*
- *Where next?*

Water security:

Grey and Sadoff (2007)

'The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies'

Cook and Bakker (2013)

Four themes, availability, vulnerability to hazards, human needs (e.g. food security) and sustainability

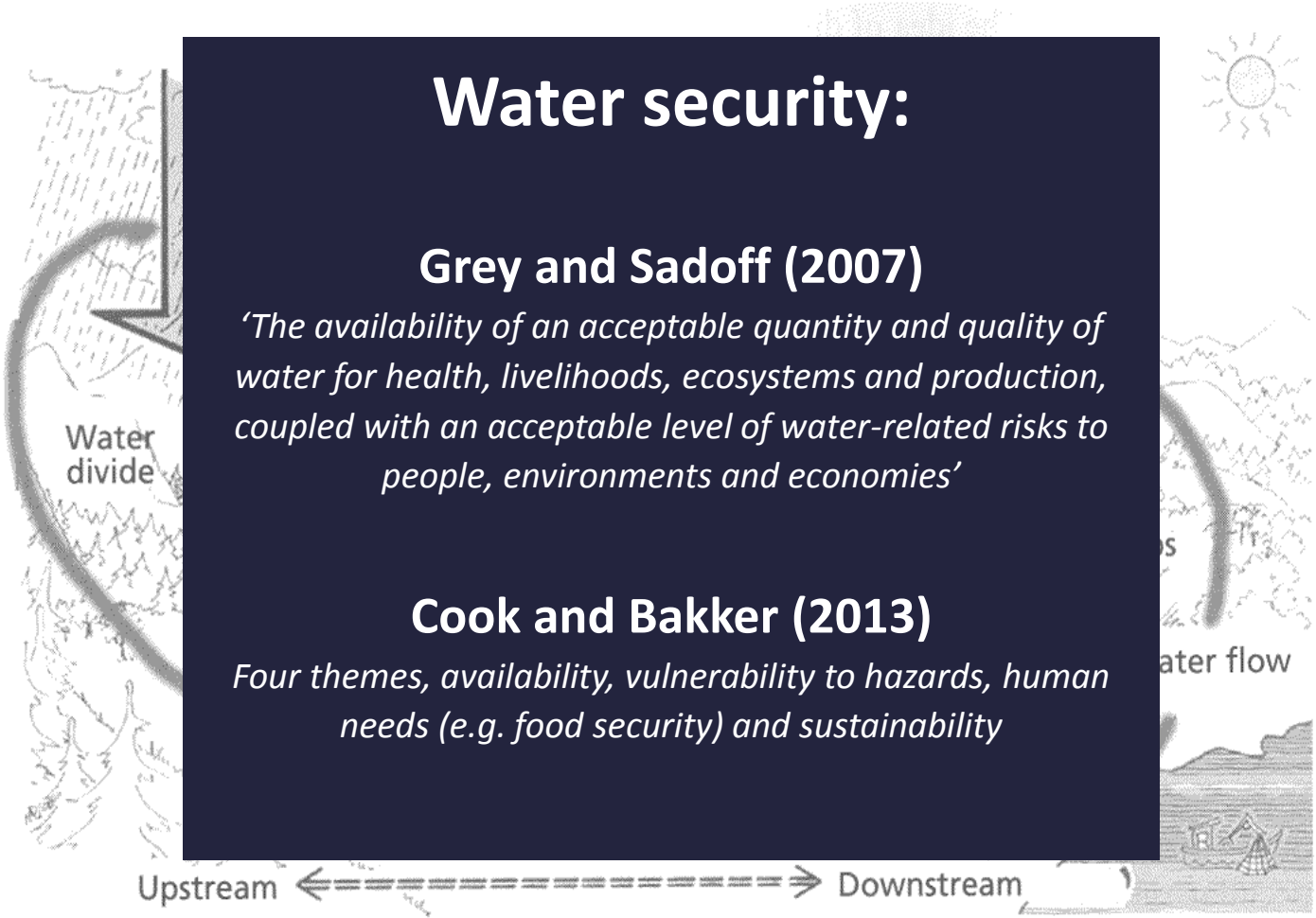


Figure source – Falkenmark and Rockstrom, 2004

Climate change and water security: What are the main challenges?

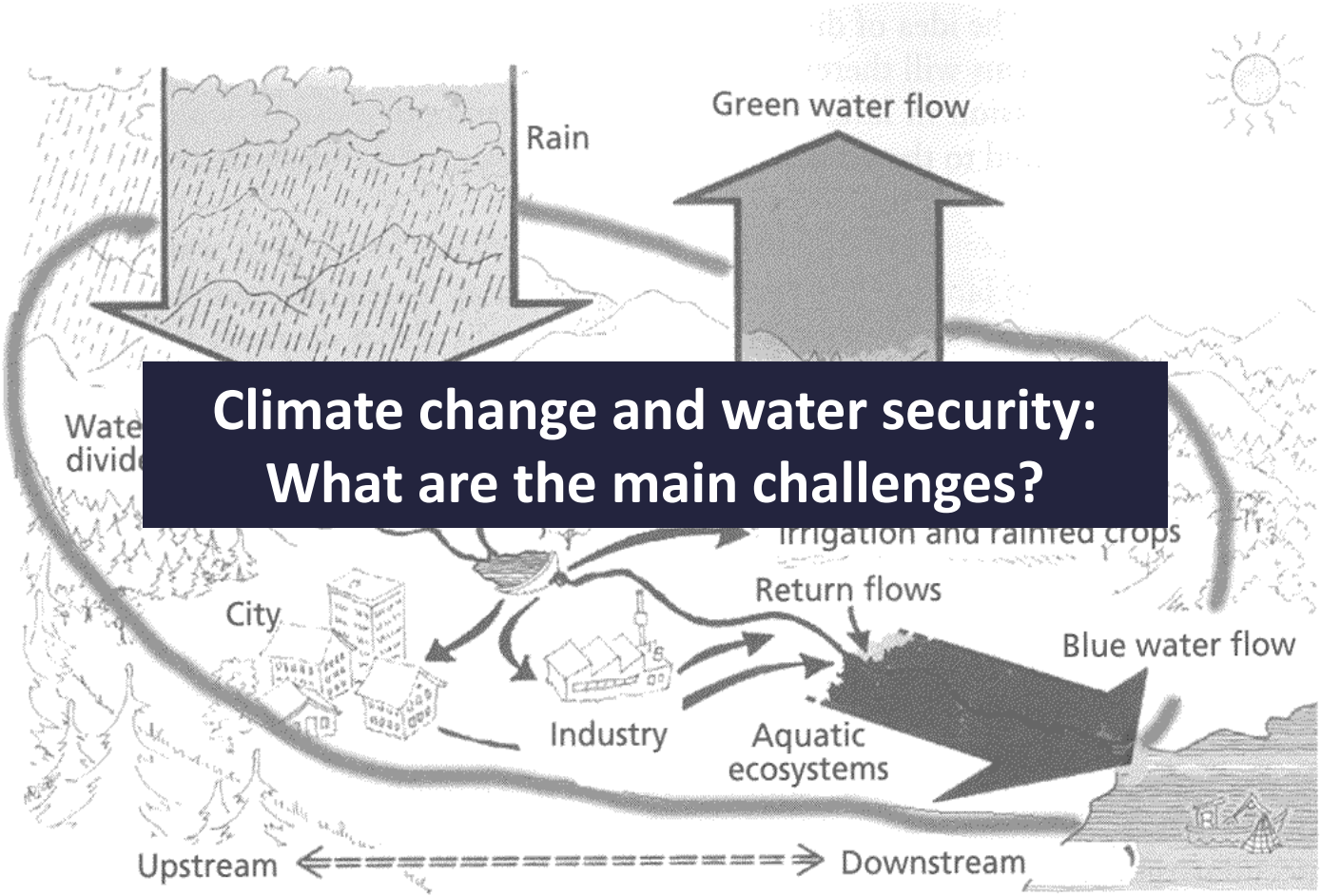
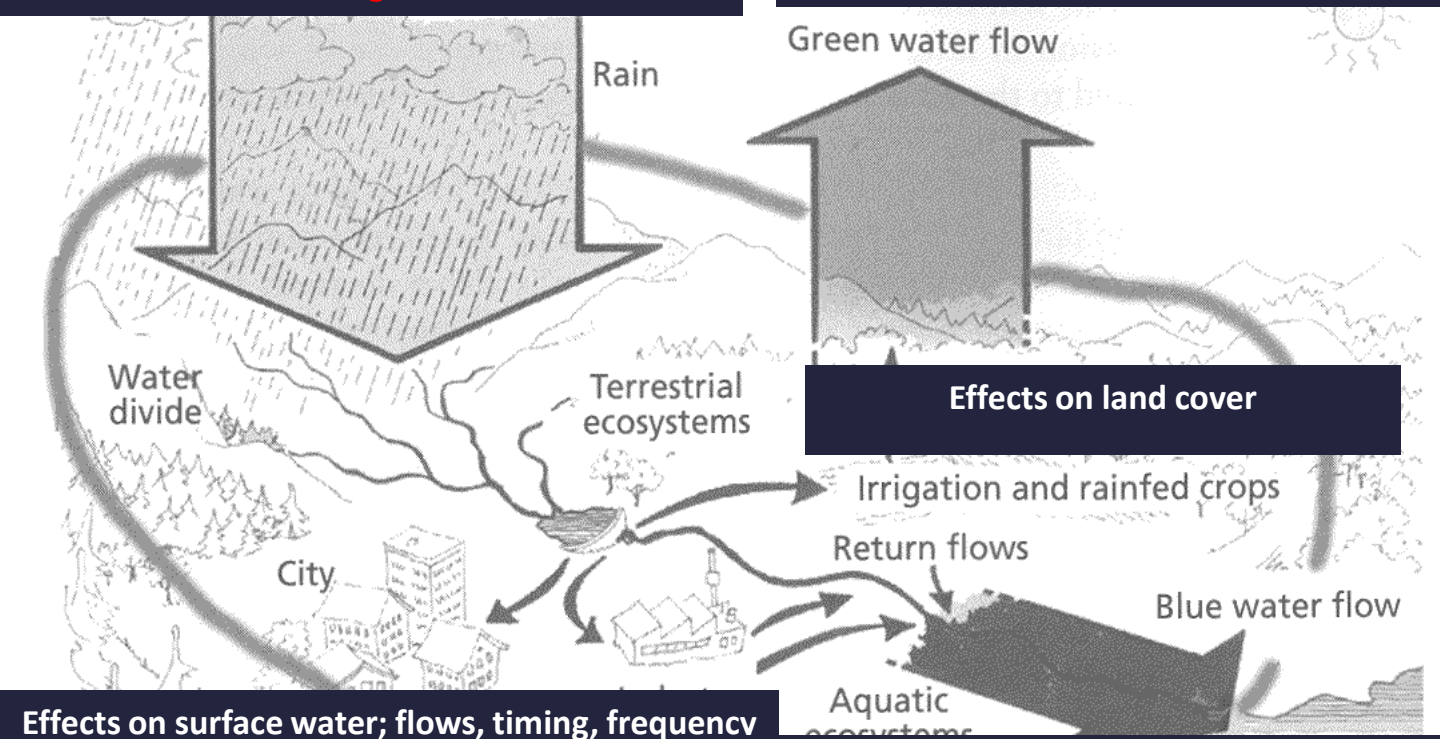


Figure source – Falkenmark and Rockstrom, 2004

Characteristics of precipitation; state, timing, amount, intensity

Snowmelt, glacial melt

Evaporative demand; higher temperatures, changes in radiation, humidity and windspeed



Effects on land cover

Effects on surface water; flows, timing, frequency of extremes, etc.
Groundwater recharge

Slow onset sea level rise, saltwater intrusion, storm surges, etc.

Physical and human dimensions

POLICYFORUM

Milly et al. 2008 Science

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be esti-

that has emerged from climate models (see figure, p. 574).

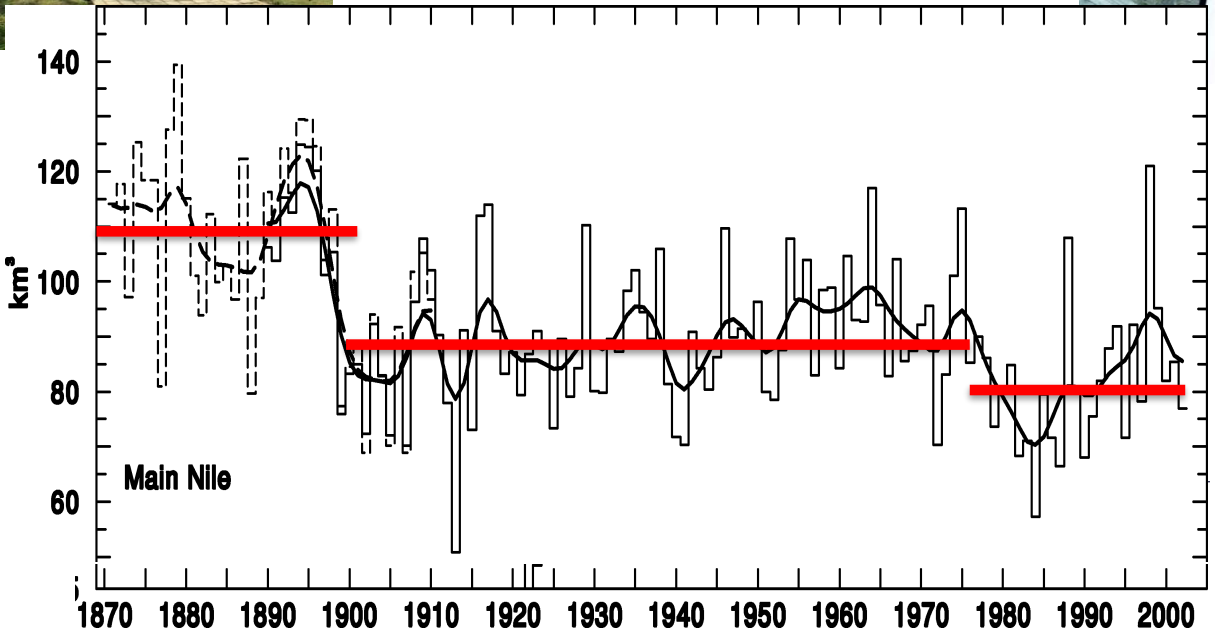
Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short

The Nile river: multi-decadal variability

Cairo - Nilometer

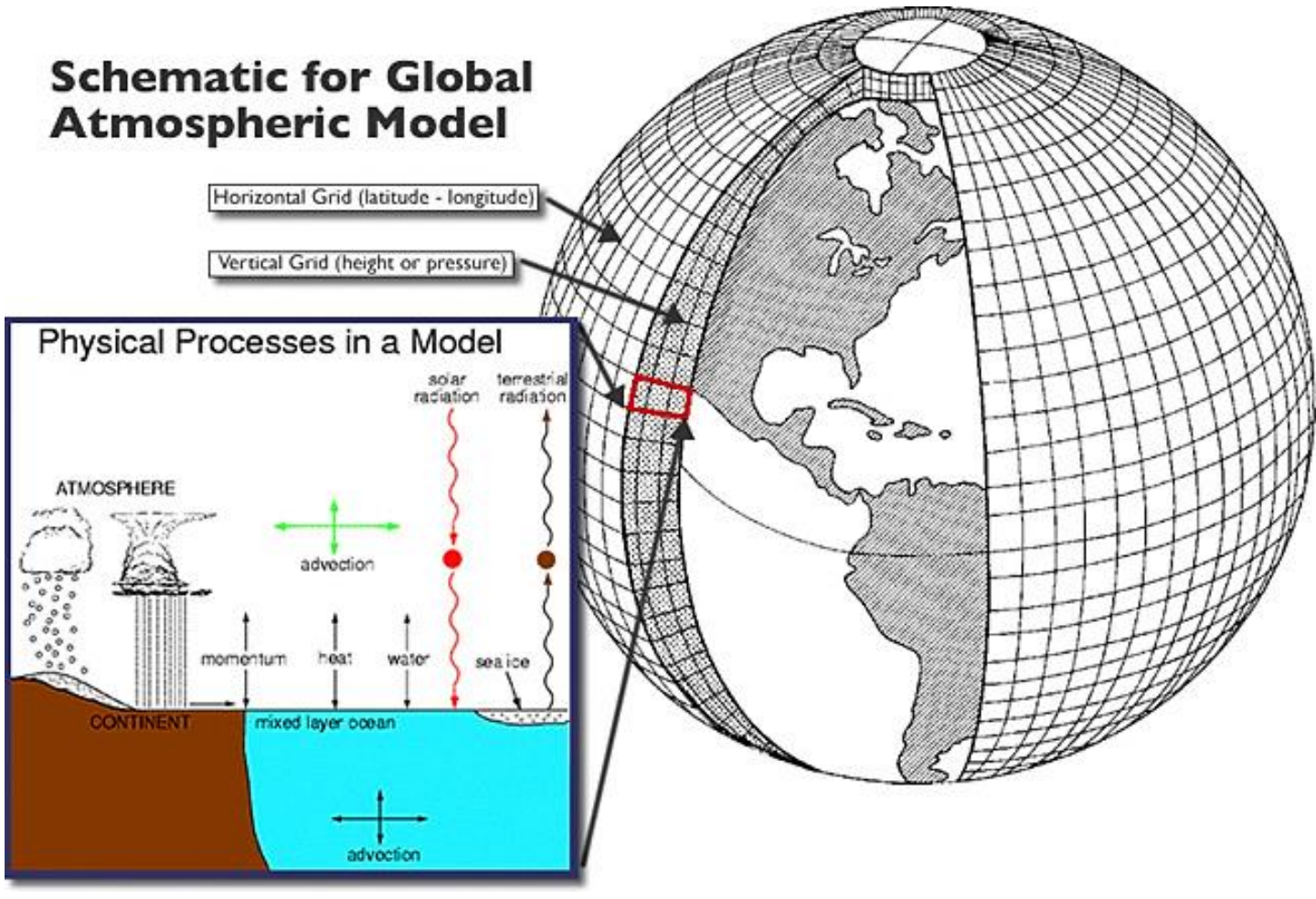
Aswan dam

The Nile: multi-decadal variability



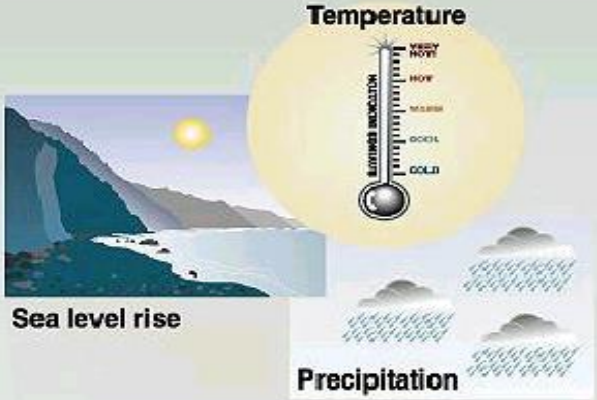
Climate impact studies

Schematic for Global Atmospheric Model



Source - http://en.wikipedia.org/wiki/Climate_model

Potential climate changes impact



Source: United States EPA

Impacts on...

Health

Weather-related mortality
Infectious diseases
Air-quality respiratory illnesses

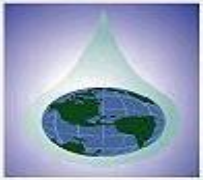
Agriculture

Crop yields
Irrigation demands

Forest

Forest composition
Geographic range of forest
Forest health and productivity

Water resources



Water supply
Water quality
Competition for water

coastal areas

Erosion of beaches
Inundation of coastal lands
additional costs to protect coastal communities

Species and natural areas

Loss of habitat and species
Cryosphere: diminishing glaciers

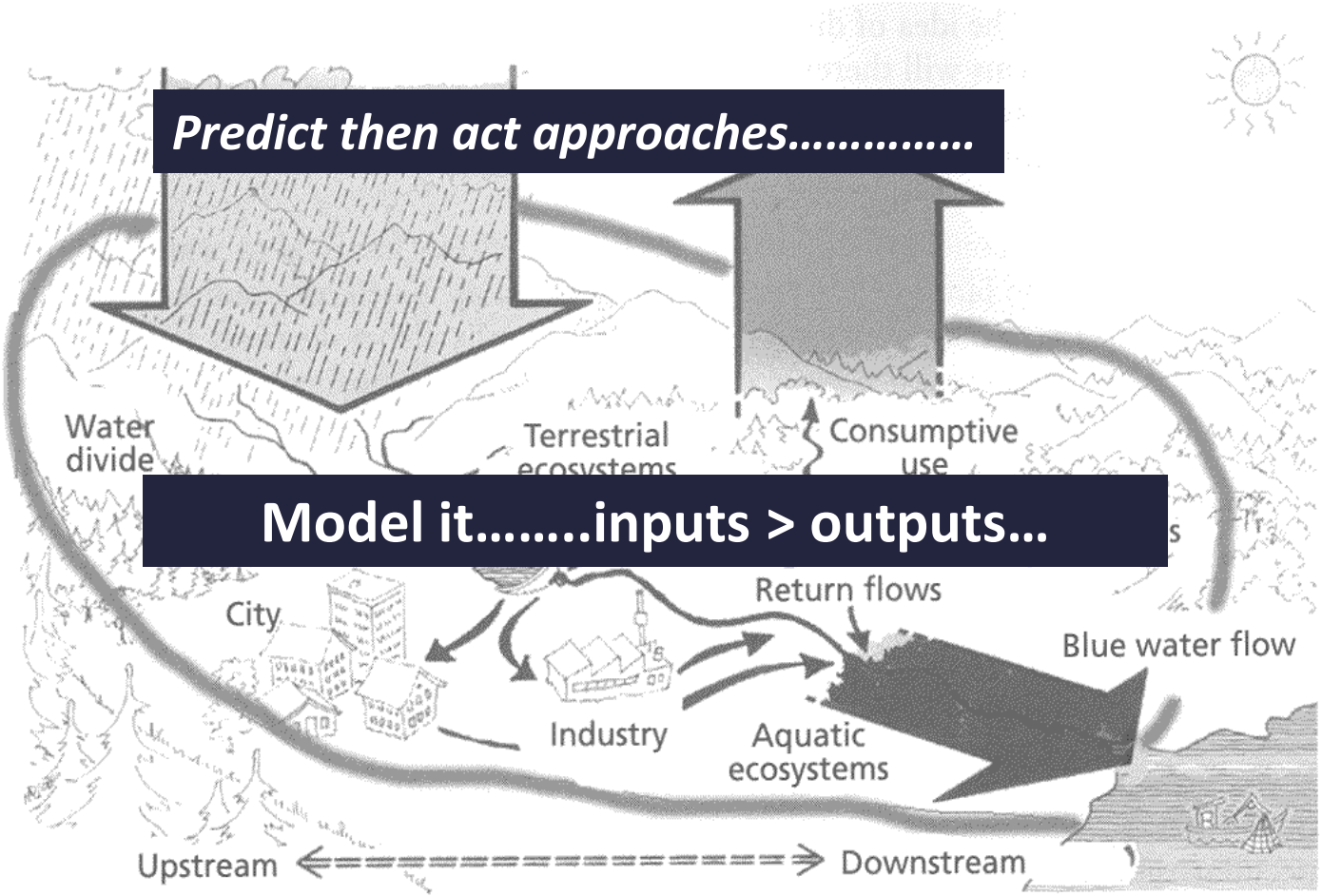
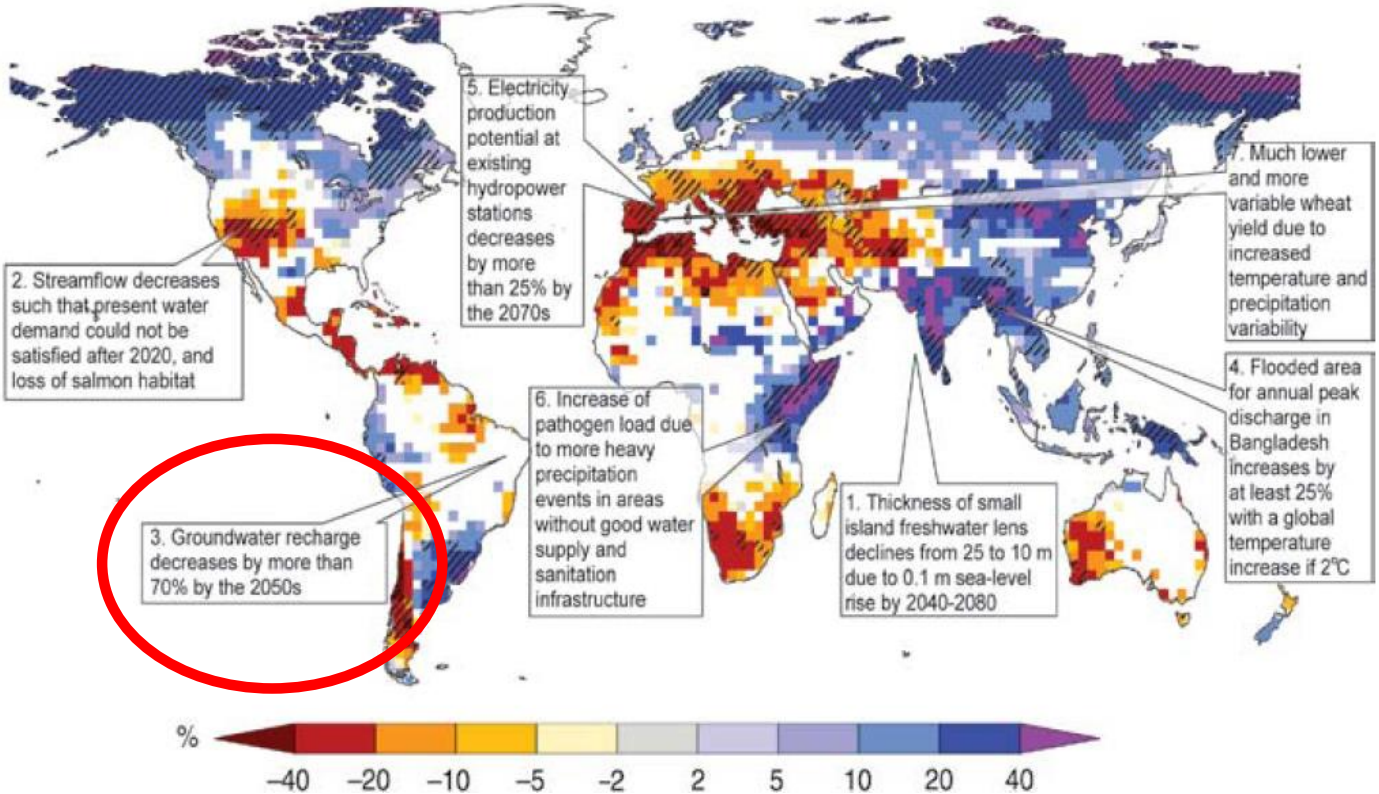


Figure source – Falkenmark and Rockstrom, 2004

Future climate change impacts related to freshwater



From Bates et al. (2008)

Future climate change impacts related to freshwater

BUT……
Impact studies
Often too far into the future…
Only consider climate…
Don't address decision-relevant factors…
Fail to capture uncertainties…

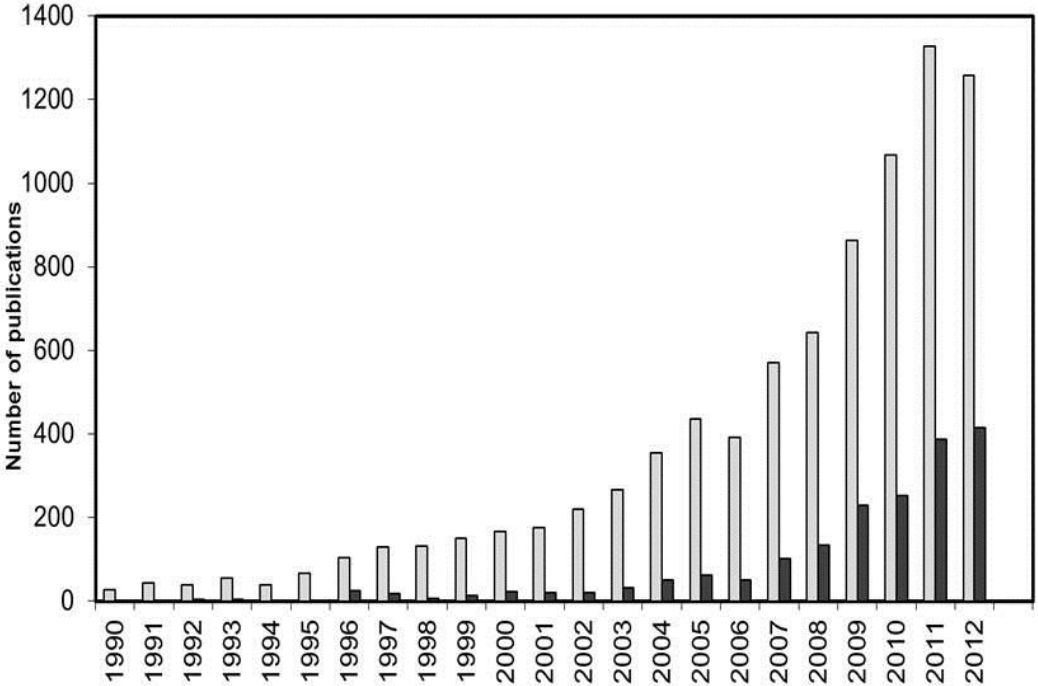
…..lack of traction with decision-makers

From Bates et al. (2008)

Late 1980s; consolidation of methods

Mid 1990s; from impacts to adaptation

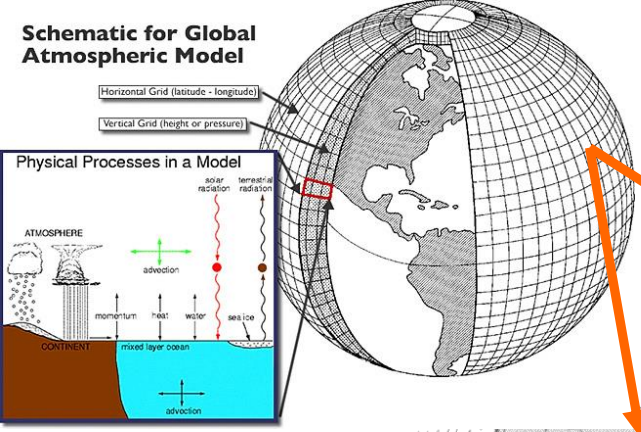
The 2000s; divergence……..



Publications per year since 1990 with word strings *'climate change water impacts'* (grey bars) and *'climate change water adaptation'* (black bars)

Divergent directions

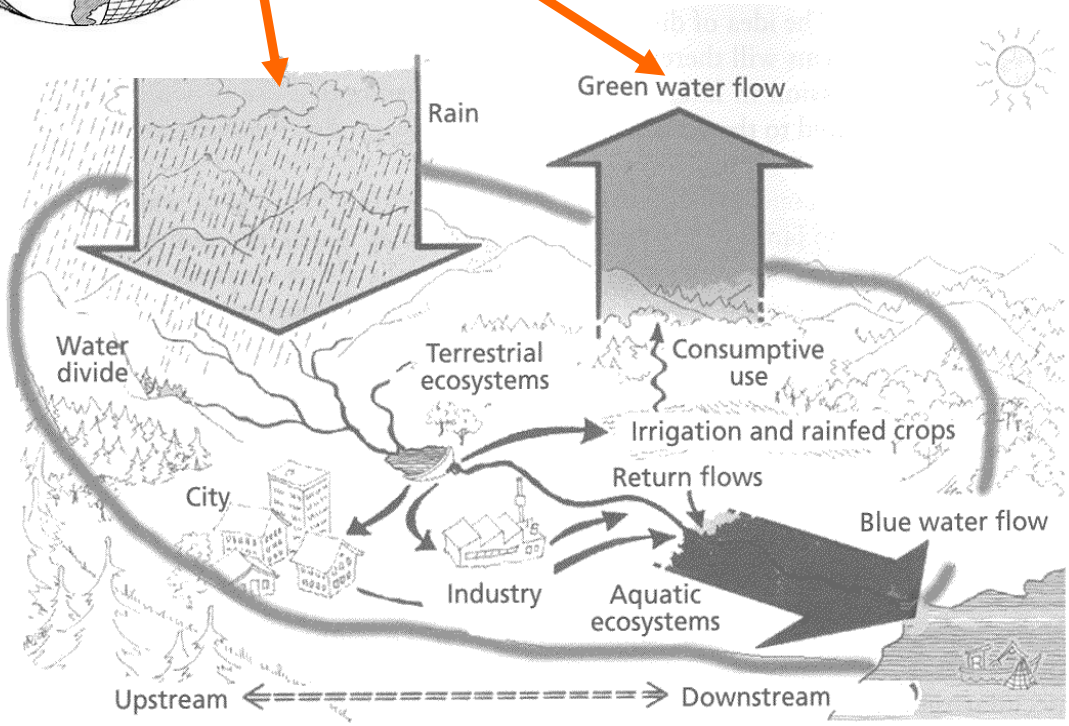
1. Scenario development (downscaling, etc.)
2. Characterising uncertainty;
   - Multiple / probabilistic climate scenarios
   - Other sources of uncertainty (model parameterisation, future demand, etc.)
3. Decision-making under uncertainty
   - Robustness, flexibility, adaptive management, etc.
4. Institutional and policy contexts
   - Detailed reviews of management / actor perspectives and capacity
5. Integration studies



1. Downscaling

Suite of techniques to;
Develop higher spatial and temporal resolution in scenario data

Weather generators, regional climate models, etc.



2. Characterising uncertainty

‘Cascade of uncertainty’

GHG Emissions

⇩

GHG Concentrations

⇩

Future global T change

How sensitive is Earth’s climate to change in GHG concentrations?

⇩

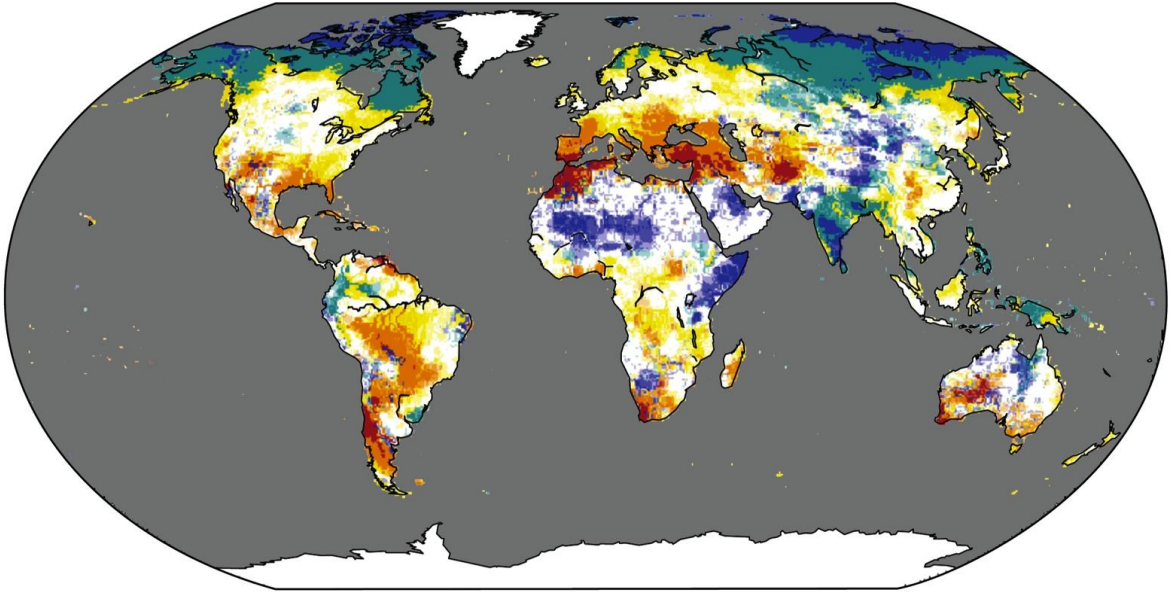
Detailed change

- **Spatial ⇔ Temporal**
- **Inter-model differences**

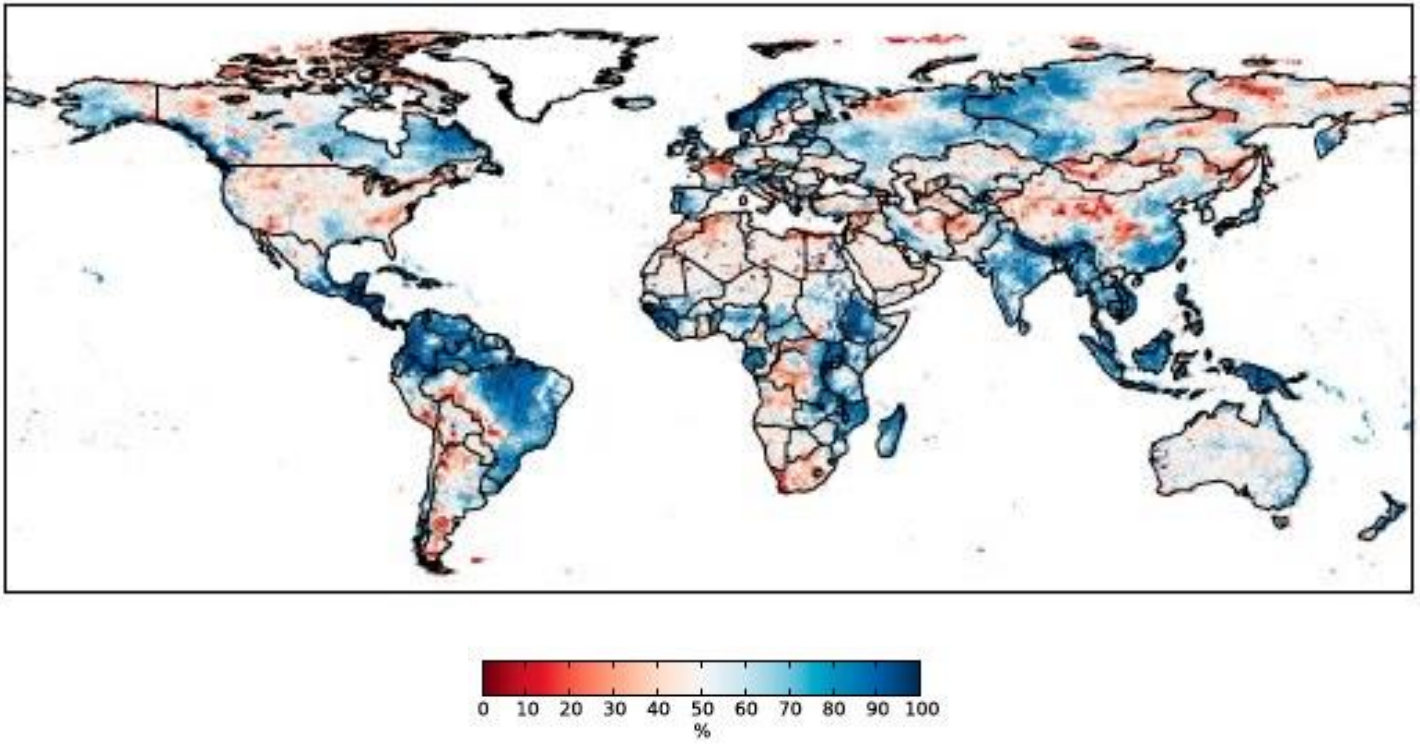
⇩

Climate change impacts

Schewe, J. et al., 2013: Multi-model assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences of the United States of America.

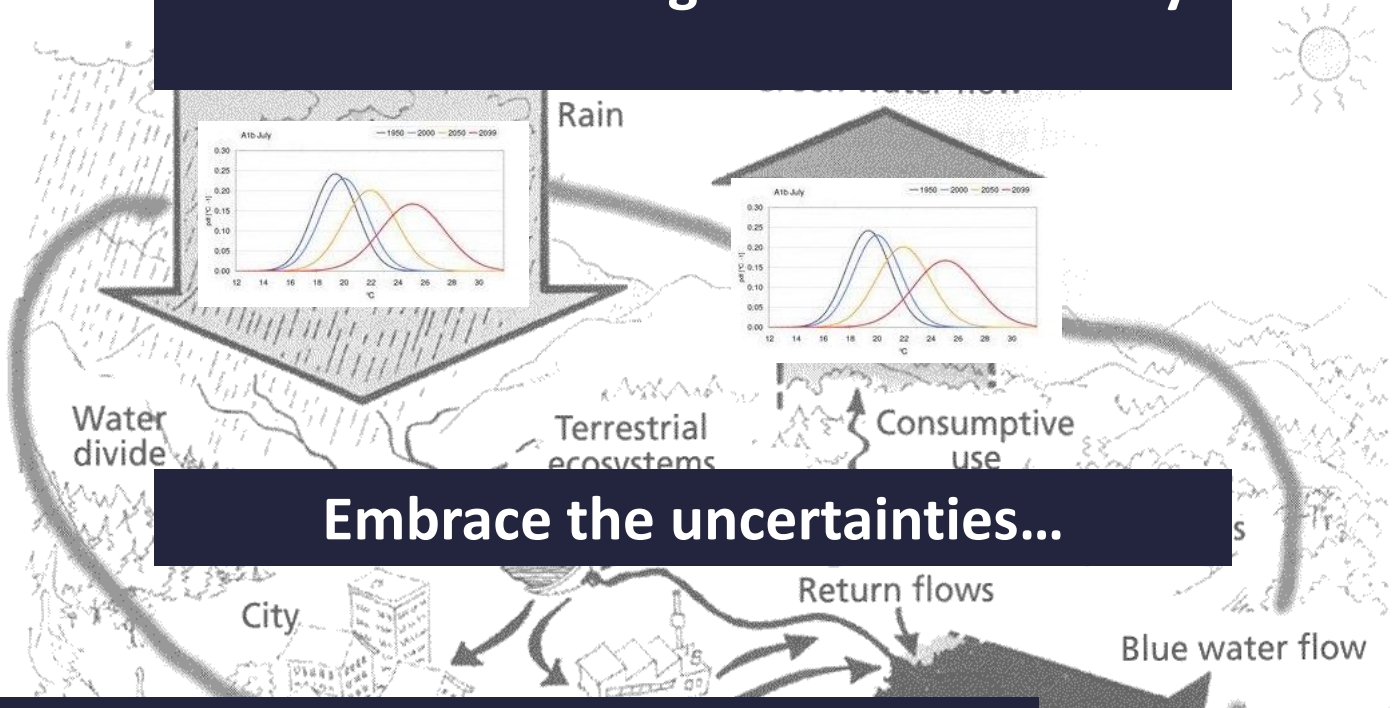


Ratio of GCM variance to total variance; in red (blue) areas, GHM (GCM) variance predominates



Schewe et al., 2013

3. Decision-making under uncertainty



Embrace the uncertainties…

‘‘‘robust decisions’’ are defined as decisions that work well even with the inclusion of various uncertainties.’

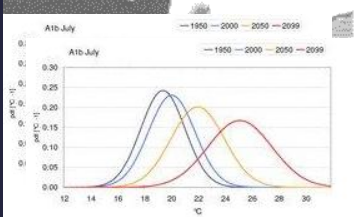


Figure source – Falkenmark and Rockstrom, 2004

4. Contexts…….

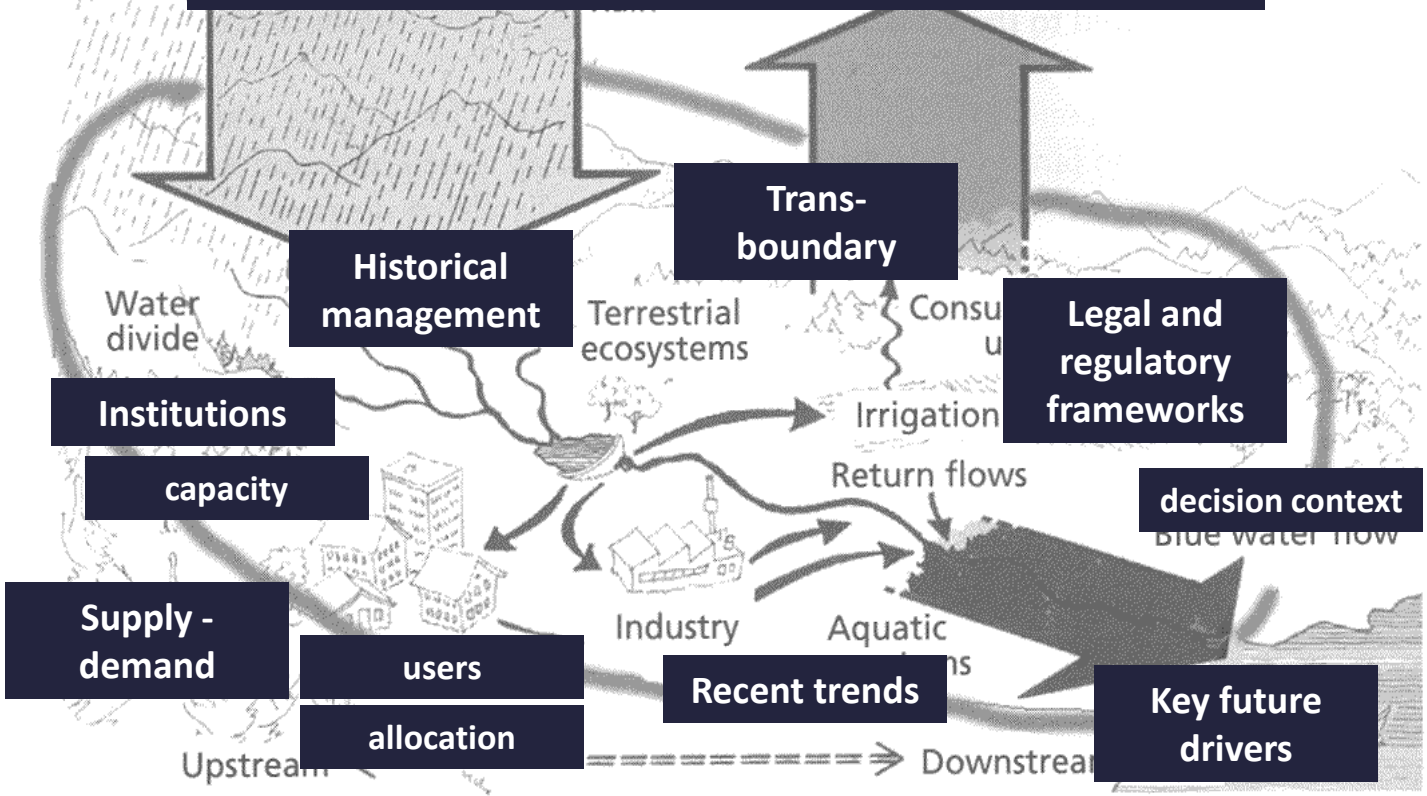
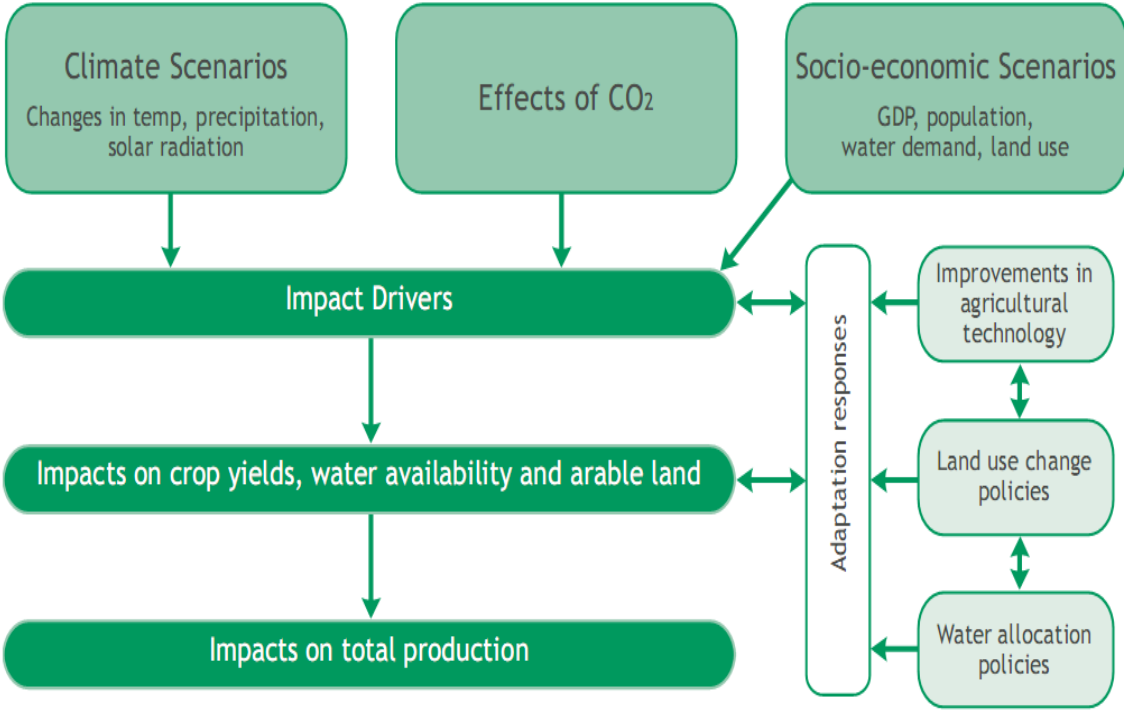


Figure source – Falkenmark and Rockstrom, 2004

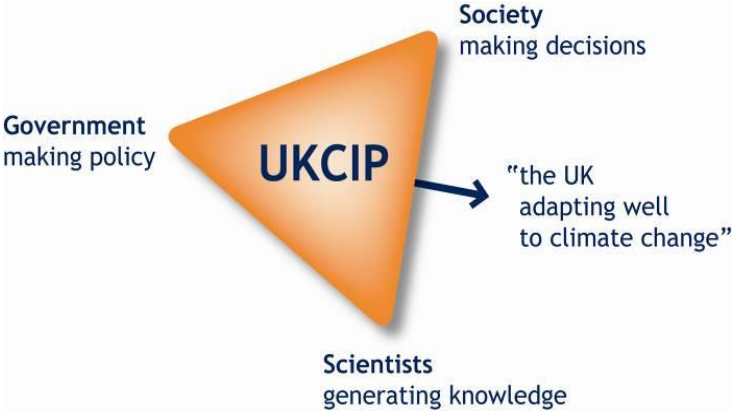
5. Integrated assessments

Climate change, CO_2 fertilization effects, SES….water demand, agricultural land conversion, etc.



Future directions

- Mainstreaming adaptation (regulatory pressures)

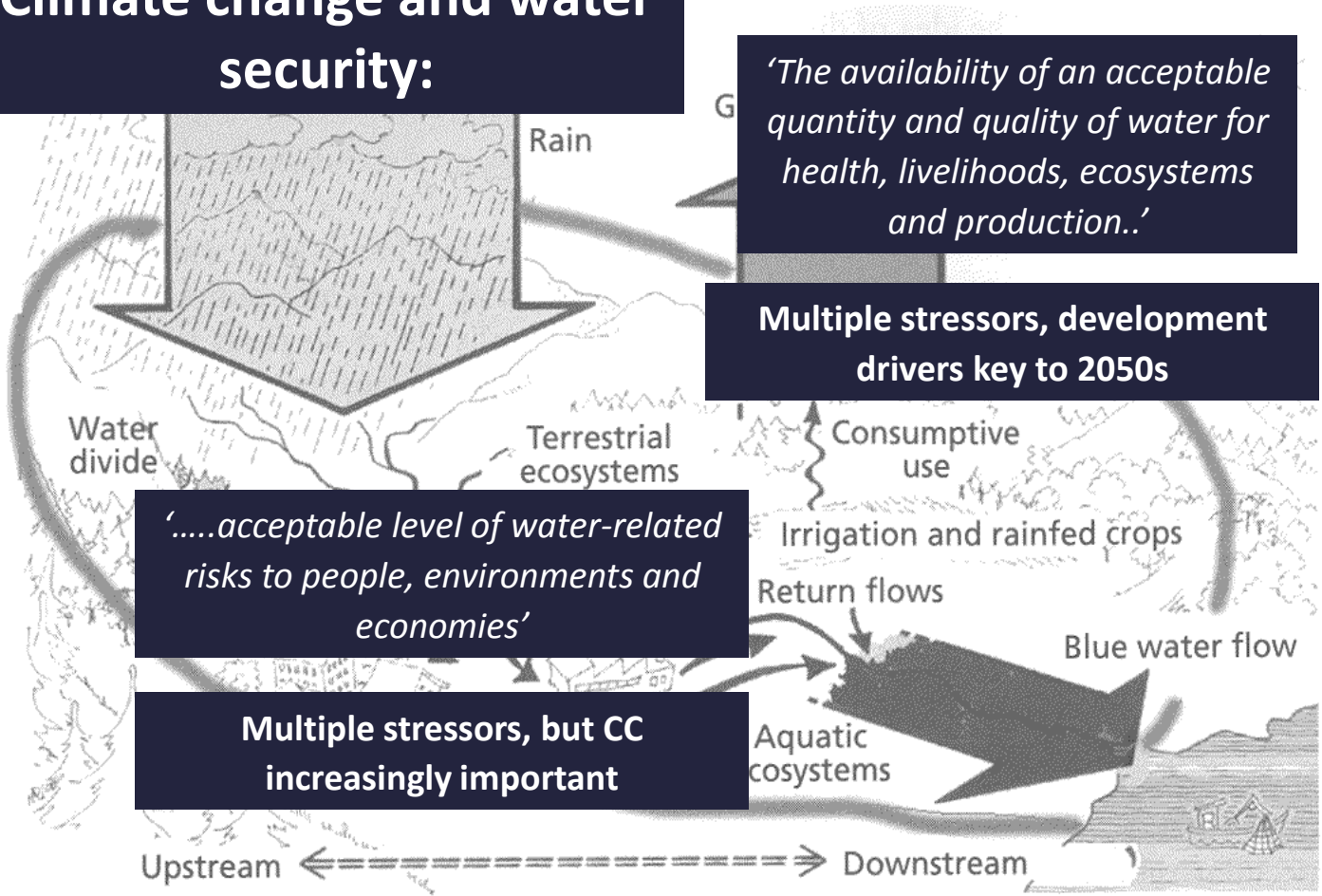


- Integration with multiple stressors, nexus approaches (water-energy-food)

Climate change and water security:

'The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production..'

Multiple stressors, development drivers key to 2050s



'.....acceptable level of water-related risks to people, environments and economies'

Multiple stressors, but CC increasingly important

Figure source – Falkenmark and Rockstrom, 2004

Thank you

References;

Conway, D. (2013) Water security in a changing climate, in B.A. Lankford, K. Bakker, M. Zeitoun and D. Conway (eds) *Water Security: Principles, Perspectives and Practices*. 81 – 100. Earthscan Publications, London.

Schewe, J. et al., 2013: Multi-model assessment of water scarcity under climate change. Proceedings of the National Academy of Sciences of the United States of America.