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Adapting Water Resource Management to Socio-Economic and Climatic Change

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Adapting Water Resource Management to Socio-Economic and Climatic Change

1. The Drivers and Timescales of Change

2.Risk-Based Assessments of Climate Change Impacts and Adaptation Measures

3. Managing the Supply-Demand Imbalance: Economic and Technological Aspects

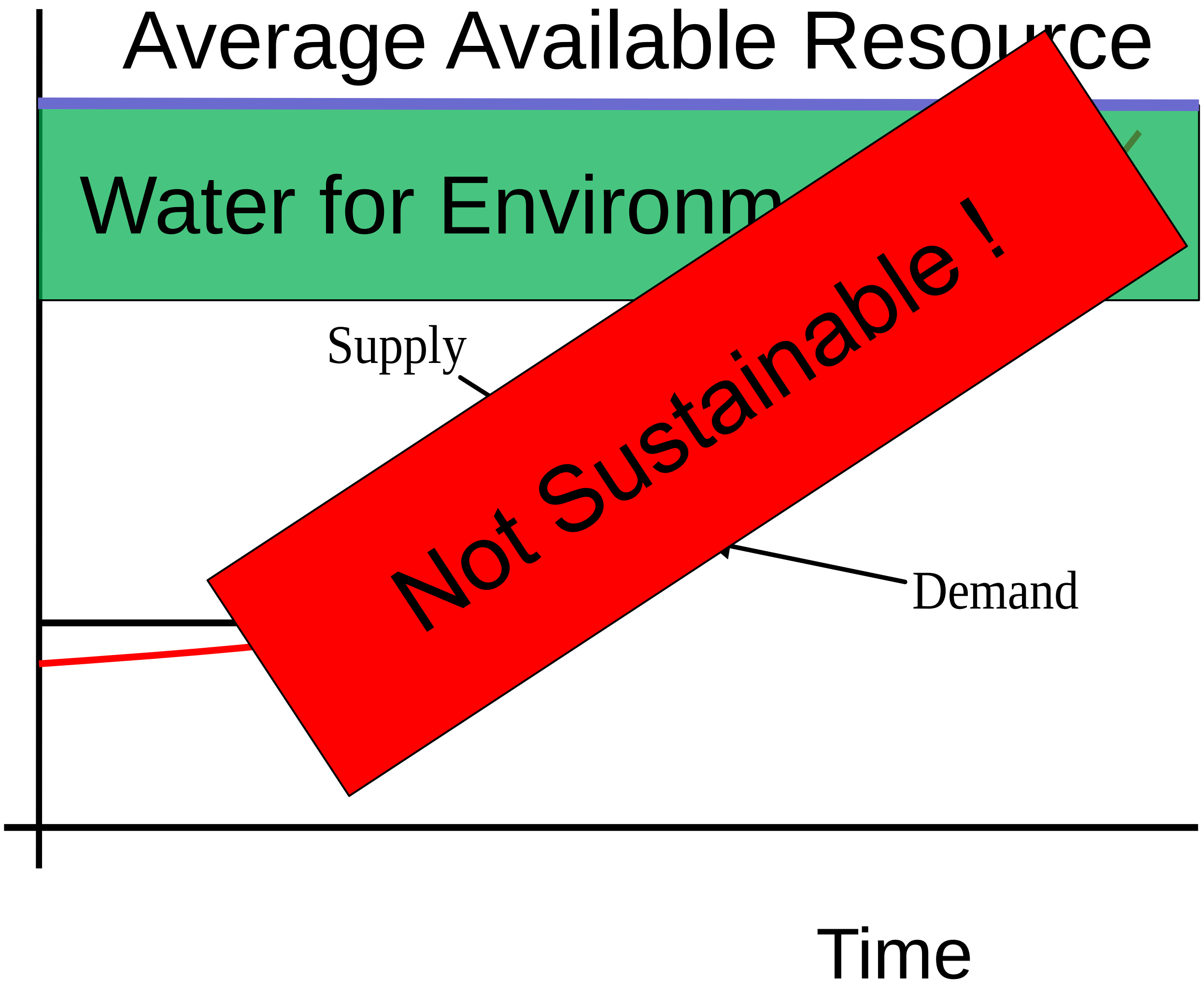
4. Modelling the Human Dimension of Adaptation

5. Conclusions

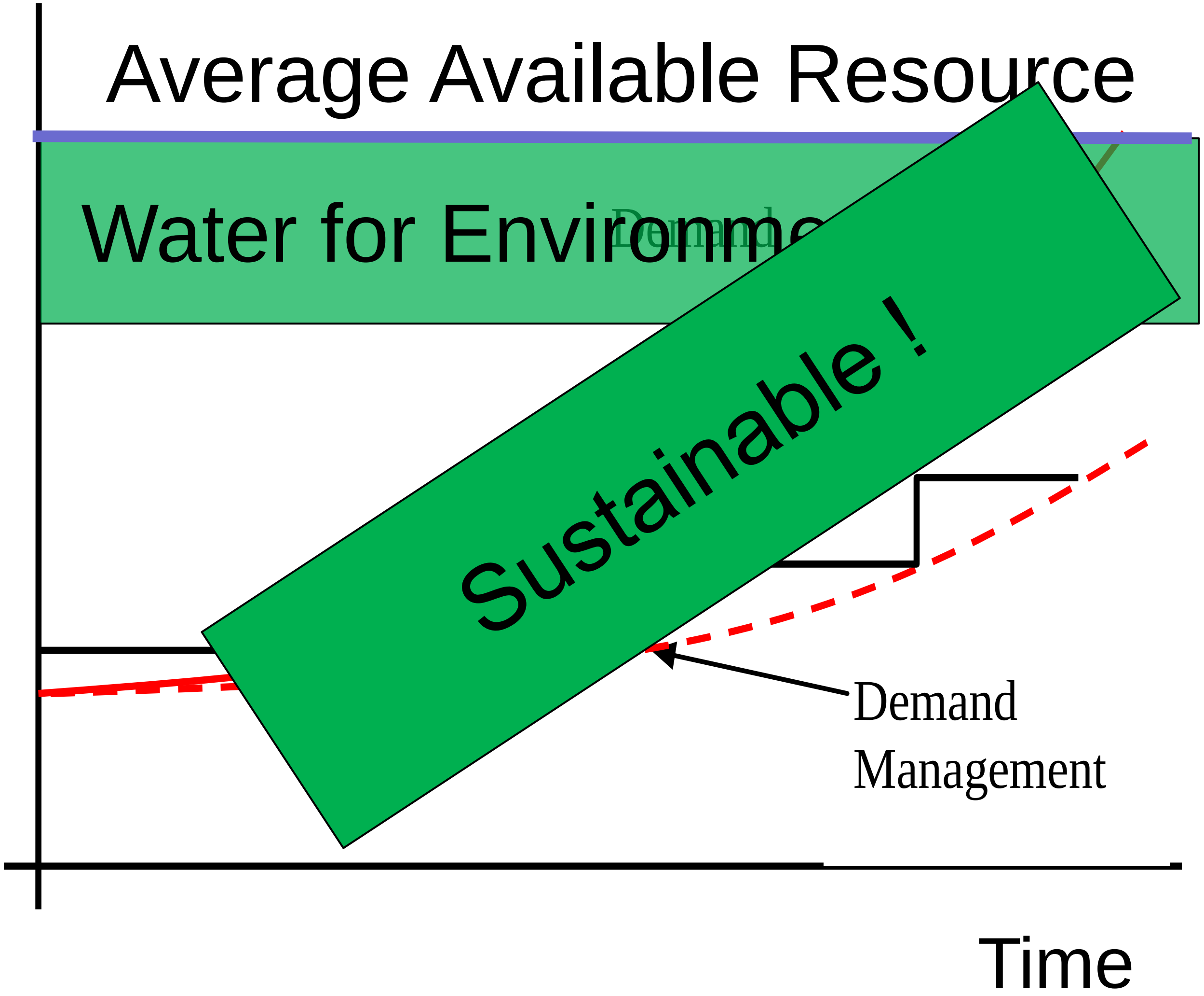
The State of Water Resources…

- Water crises are well documented (WWAP Reports) and will intensify over coming decades
- Main drivers are population growth, economic growth in developing economies (eg BRICS and MINT), globalization, lifestyle changes, and climate change in the longer term
- Water resource systems and water environment under increasing stress due to over-abstraction of surface and groundwater, and vulnerable to natural climatic variability/drought; **supply-demand gaps developing**
- Not enough focus on water use efficiency and demand management
- But main preoccupation of governments and water sector is threat from anthropogenic climate change.

The Supply-Side Approach



The Twin-Track Approach



The State of Water Resources Research…

- Dominated by climate change impact assessments based on climate model (GCM) outputs
- Large uncertainty associated with outcomes from assessments – what to do?
- Some research on adaptation, but skewed towards climate change, and not the wider problem of adapting to water scarcity associated with growth in demand
- Limited focus on economic analyses of how to close the demand-supply gaps, and on water use efficiency/demand management

IPCC Fifth Assessment Report: Changes in Extreme Events (2013)

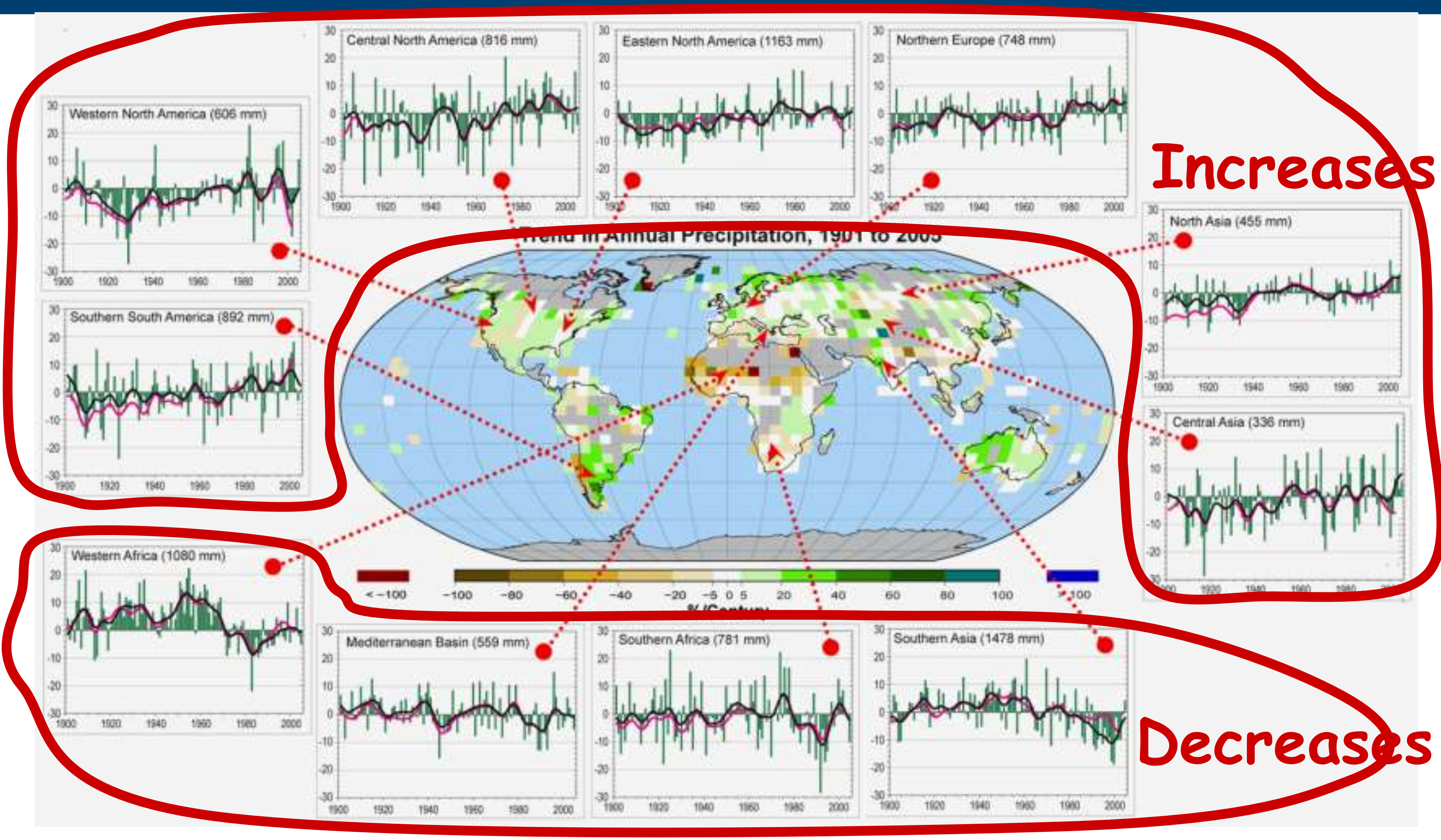
“ In summary, the current assessment concludes that there is not enough evidence at present to suggest more than ***low confidence in a global-scale observed trend in drought****…….. Based on updated studies, AR4 conclusions regarding global increasing trends in drought since the 1970s were probably overstated.”*

IPCC Special Report on ‘Managing the Risks of Extreme Events and Disasters’ (2012)

“Projected changes in climate extremes under different emissions scenario generally do not strongly diverge in the coming two to three decades, but ***these signals are relatively small compared to natural climate variability over this time frame****.* *Even the sign of projected changes in some climate extremes over this time frame is uncertain.”*

(but some countries are projected to run out of water in the next few decades!)

Land precipitation is changing significantly over broad areas



Smoothed annual anomalies for precipitation (%) over land from 1900 to 2005; other regions are dominated by variability (Trenberth (2008) Anticipated and Observed Trends in the Global Hydrological Cycle. American Geophysical Union 2008 Spring Meeting, Fort Lauderdale,FL)

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Approaches to Risk-based Impact Assessment

- **Top-down** impact assessment: downscaled climate model (GCM/RCM) scenarios
- **Bottom-up** reactive methods that focus on reducing vulnerability to past and present climate variability: coping with climate at the level of individuals, households and communities.

GCM Precipitation Simulation

- GCM precipitation simulations are less robust than for other GCM fields, such as temperature (Rocheta et al 2014).
- GCMs do not reproduce natural interannual variability; they generally underestimate the variance/autocorrelation/ Hurst coefficient of the observed series.

GCM Precipitation Simulation

- Yangtze Basin: ‘*Until projections of the strength and location of the monsoon under a future climate improve, large uncertainties in the direction and magnitude of future change in discharge will remain*’ (Birkinshaw et al 2017).

Simulating long term climatic variability

- Historical long-term climatic variability can be simulated by stationary stochastic models (eg FGN/FDARMA/Hurst-Kolmogorov)
- Derive information on long-term variability from palaeo records; combine with statistics of instrumental record to parameterize model
- For impact assessment, incorporate usable information from GCMs eg temperature scenarios

Bottom-up risk-based vulnerability assessments

- Brown and Wilby (2012) advocated risk-based vulnerability assessments of water resource systems to assess the risks that coping thresholds will be exceeded: **Synthetic Hydrology** re-invented!
- Harvard Water Programme (1950s/1960s) invented **Synthetic Hydrology**:
  - Stochastic model + Monte Carlo Simulation

to assess the reliability of water resource systems under a wider range of conditions than a historical record could provide:

- **Stress testing** of water resource systems

‘Beyond Downscaling’: Alliance for Global Water Adaptation (AGWA: World Bank)

A decision-support framework for bottom-up climate risk assessment based on economic analytical methodologies that can:

(a) estimate the costs of maintaining multiple options and flexibility;

(b) evaluate the trade-offs between waiting for more certain information before implementation versus acting in the short term with less information;

(c) design multiple decision-making pathways.

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2030 Water Resources Group

- Formed in 2008 to contribute new insights to the increasingly critical issue of water resource scarcity: ***Charting Our Water Future (2008)***
- Members include McKinsey & Company, the World Bank Group (IFC),and a consortium of business partners:
  The Barilla Group, The Coca Cola Company, Nestlé SA, New Holland Agriculture, SAB Miller PLC, Standard Chartered Bank and Syngenta AG.

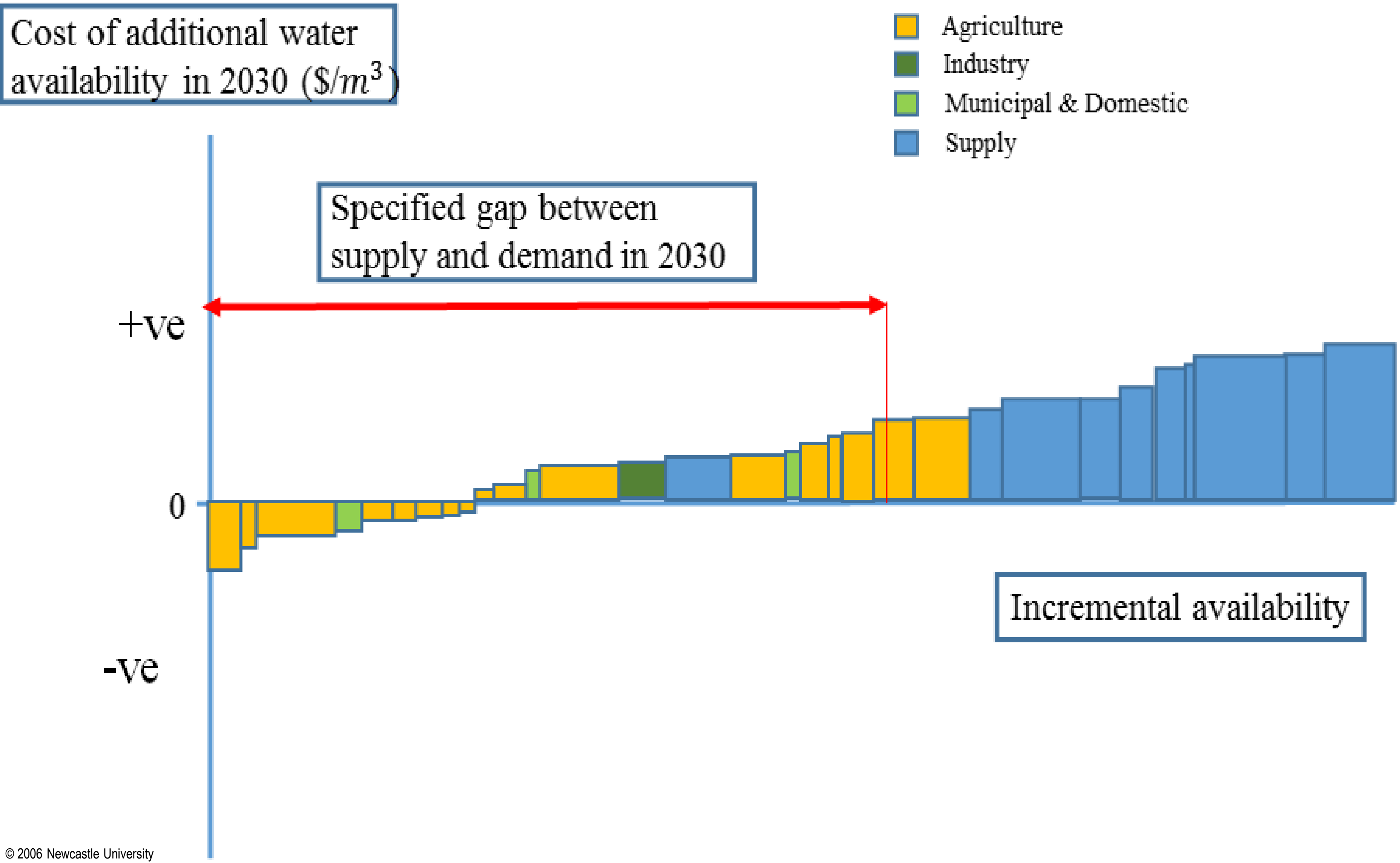
2030 WRG Findings

- Demand-supply gaps growing. By 2030, water supplies will satisfy only 60 percent of global demand, and less than 50 percent in many developing regions where water supply is already under stress, including China, India, and South Africa.
- Gaps closed locally through over-abstraction eg from groundwater
- Should mobilize investments, particularly in water use efficiency, but not happening.
- World Economic Forum Global Risks Report (2015) identified Water Crises as the global risk of highest concern for the next 10 years; still high risk in 2019 Report.

2030 WRG: Business Opportunities

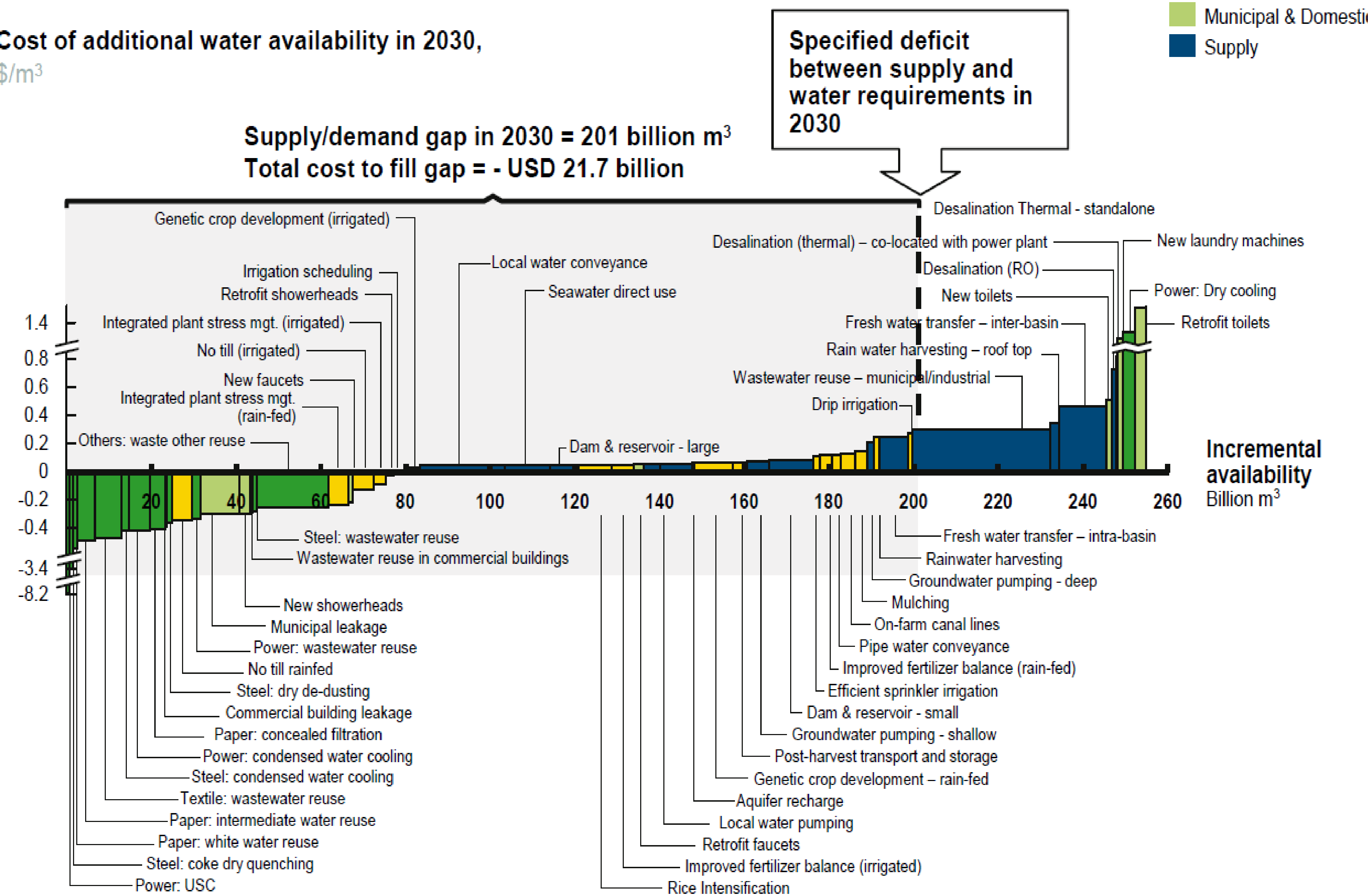
- ***Charting our Water Future*** summarizes the business opportunities for achieving improvements in water use efficiency/productivity in three main areas:
  - water treatment and distribution;
  - water-intensive industrial and power processes;
  - water usage in agriculture.

2030 WRG: Water Availability Cost Curve



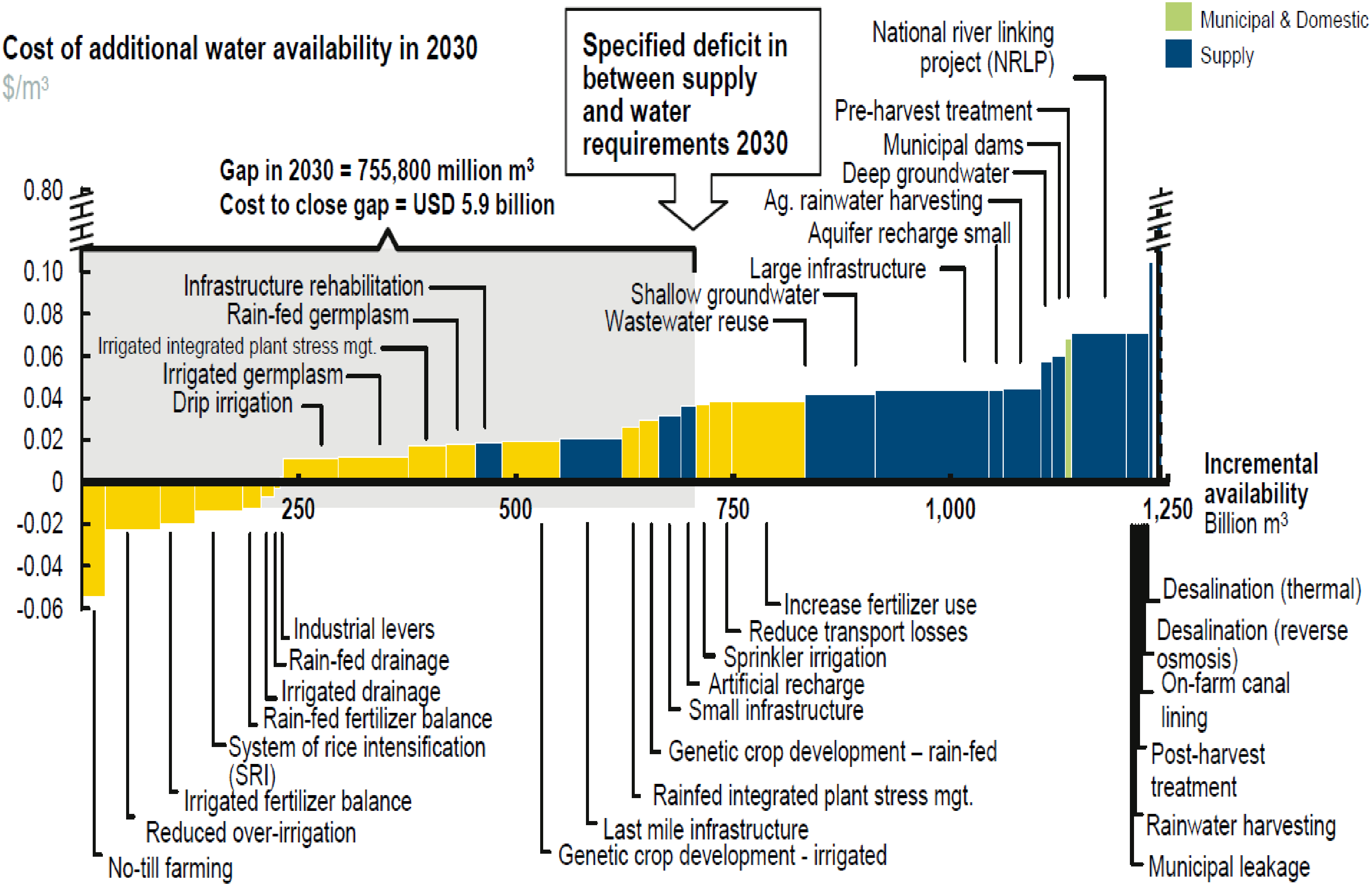
China – Water availability cost curve

Cost of additional water availability in 2030,
$/m³



SOURCE: 2030 Water Resources Group

India – Water availability cost curve



SOURCE: 2030 Water Resources Group

Cost of Closing the Global Water Gap (WRG,2008)

- Based on the Cost Curve approach, water use efficiency investments dominate in closing the water gap: **pathway to sustainability**
- Closing the Water Gap at the global scale is estimated to cost **$50 Billion per annum**
- Closing the Water Gap with the supply-side approach is estimated to cost **an additional $200 Billion per annum** - large cost premium.
- 2030 WRG has entered the water sector; mobilizing unique public-private-expert-civil society network. Support to 15 countries by 2016.

Technological Opportunities: Integrated Real-time Operational Control

- Enabled by major developments in sensor, communication and computational technologies
- Improve inefficient operating procedures; more transparency on water use
- Elements in place already eg real-time control of urban water distribution systems, hydraulic structures, irrigation canals

but fragmented piecemeal approach.

- Need integrated approach at whole river basin/regional /national levels covering all functions (water supply, flood and pollution control, irrigation, navigation etc) to control all water uses more efficiently/regulate demand

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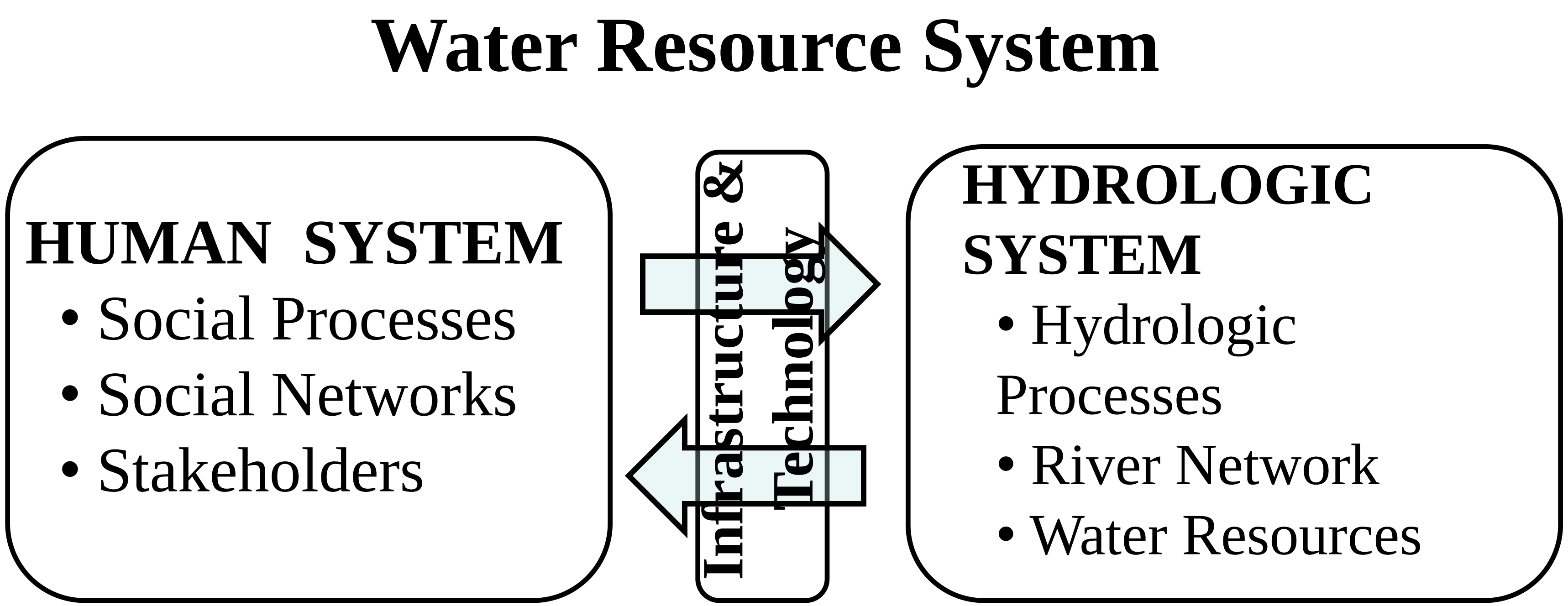
The Human Dimension of Adaptation

- Multiple assumptions made about human responses eg of Farmers, Urban Dwellers, Companies.
- What levers need to be activated to achieve greater water use efficiency/wise use of water?
- Human dimension is a black box in water resource system modelling.
- Coupled Human and Natural Systems (CHANS) modelling used in ecosystem research.

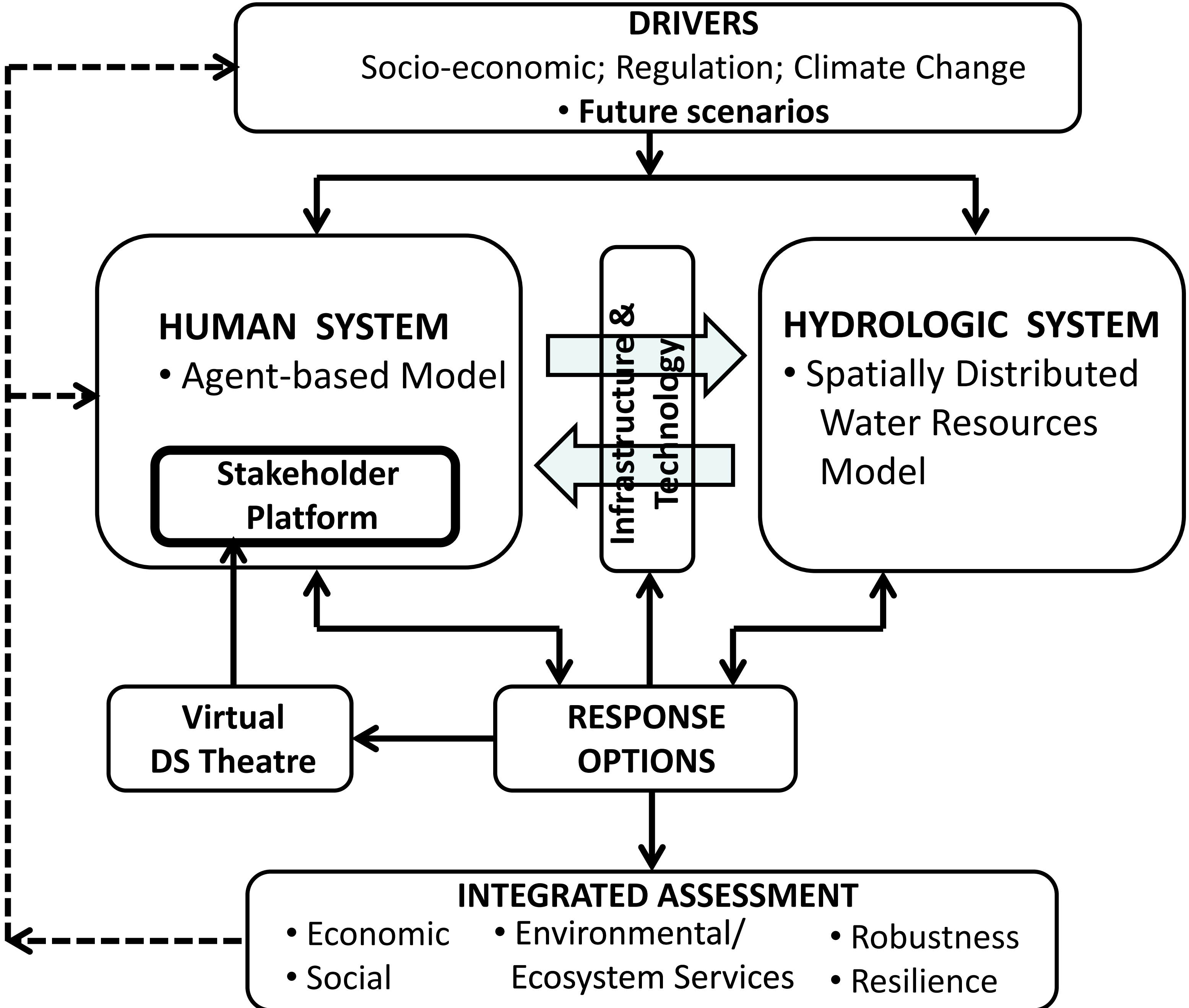
Water Resource System as Coupled Human and Hydrologic System (CHAHS)



Agent-based Modelling (ABM)

- Representing complexity of human behaviour is beyond ABM, but can explore modes of behaviour eg utility maximisation or satisficing
- Promote social learning: help develop trust and cooperation between stakeholders
- ABM not mature:
  - exploratory – look for emergent behaviour
  - judgemental validation – need survey data.

CHAHS Modelling and Decision Support Framework



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Conclusions(1/4)

- If left to its own devices, water sector will not close water gaps (2030 WRG, 2009)
- Water is not generally part of mainstream government economic planning – water sector expected to 'catch up' without adequate investment
- Need greater focus on water saving technologies and efficient water use to close water gap(s) in coming decades: supply-side approach too expensive in monetary and environmental terms

Conclusions(2/4)

- Expect that climate change will make things worse in the longer term but incremental adaptation needed regardless – pathway to sustainability
- Governance challenges associated with achieving paradigm shift – enable polycentric approach with hierarchical real-time control at basin/regional scales?
- Shift away from top-down GCM downscaling to bottom-up local-scale vulnerability assessments: stress-testing using stochastic modelling of natural climatic variability (+ useable GCM information)

Conclusions(3/4)

- Revisit Harvard Water Programme (Maass et al 1962) to ensure legacy is not lost: integration of
  - Economic analysis
  - Synthetic hydrology
  - Systems analysis and operations research

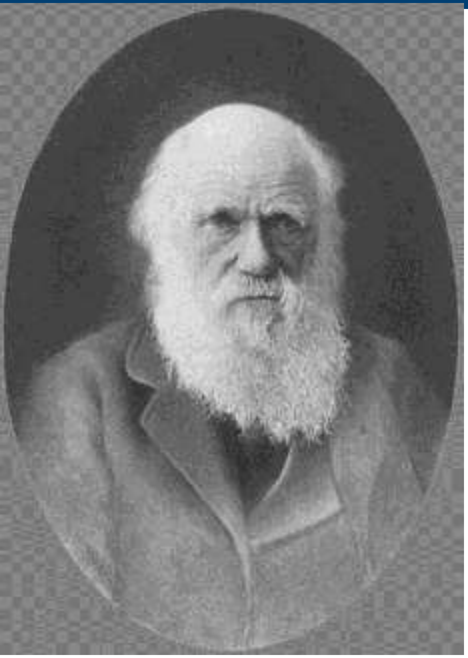
(and acquire a copy of Loucks and Van Beek, 2017)

- Need to explore the human dimension of adaptation explicitly using Coupled Human and Hydrologic System Modelling within a DPSIR framework:
  - could be used to carry out integrated assessments of the 2030 WRG cost curve options (Responses) for closing the water gap(s).

Conclusions(4/4)

Restore the Balance of Water Resources Research

Darwin on Change……..



“It is not the strongest
of the species that survive,
nor the most intelligent,
but the one most responsive
to change”

Charles Darwin

Rutherford on Funding……..

"We've got no money, so we've got to think."

Ernest Rutherford

Thank you for your attention.