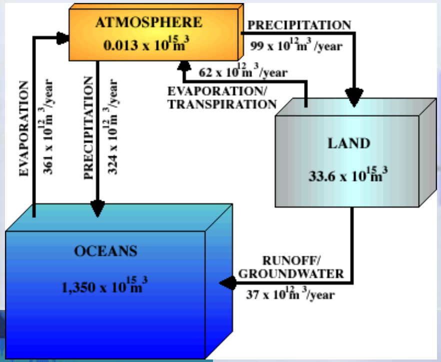
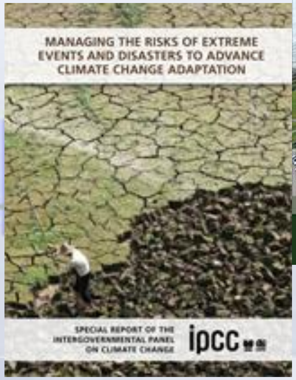
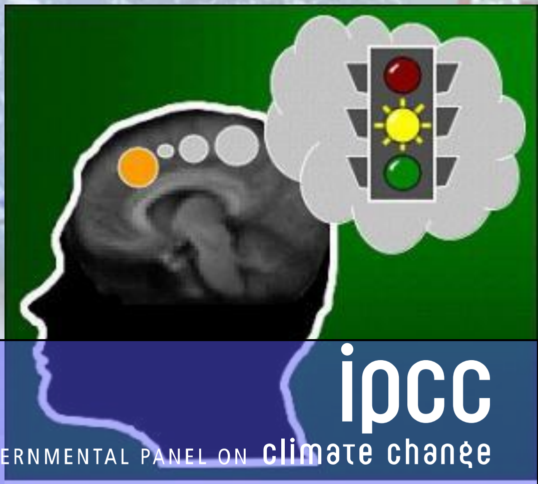
IPCC AR5 Working Group II:
Observations to support adaptation planning and implementation

Roger S. Pulwarty

NOAA, GCOS, IPCC







ipcc
INTERGOVERNMENTAL PANEL ON climate change

So what's new (in the Fifth Assessment WGII) ?

•<u>Newer climate models and scenarios:</u>

•<u>Larger base of knowledge</u>-expanded treatment of human systems, adaptation, and the ocean."

- **<u>Adoption of a risk paradigm:</u>**

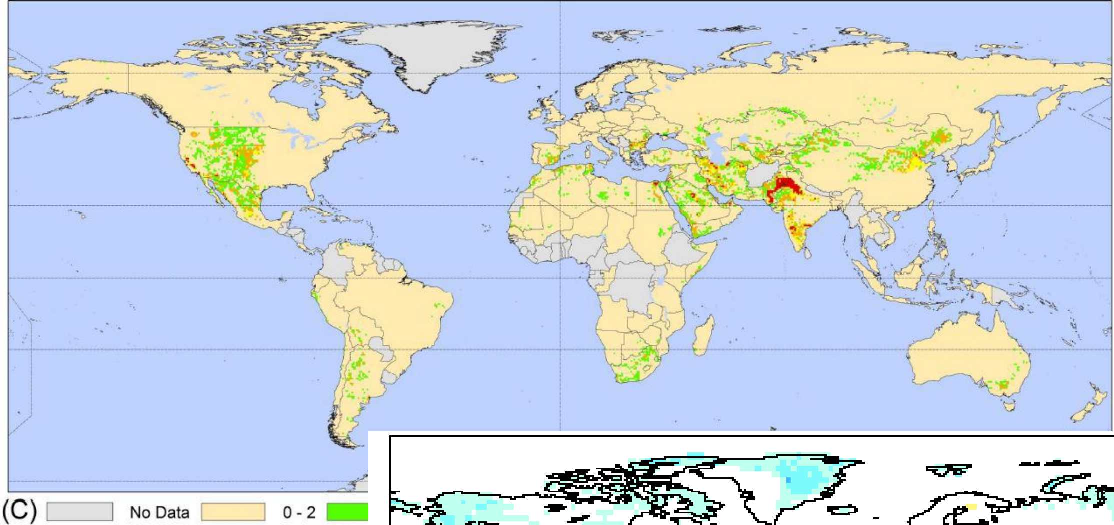
  In which climate change is described as increasing or decreasing the risk associated with various outcomes.

- **<u>Greater emphasis on practice and on social science inputs:</u>**

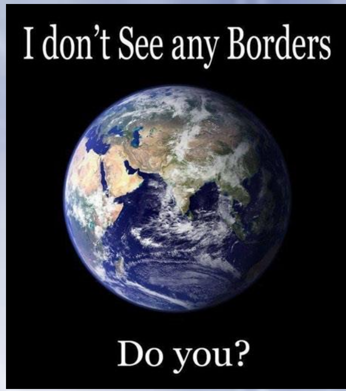
  Emphasis on adaptation theory, techniques, and adaptation experience to date, as well as to *"the decision-making context"*

- **<u>Addressing detection and attribution:</u>**

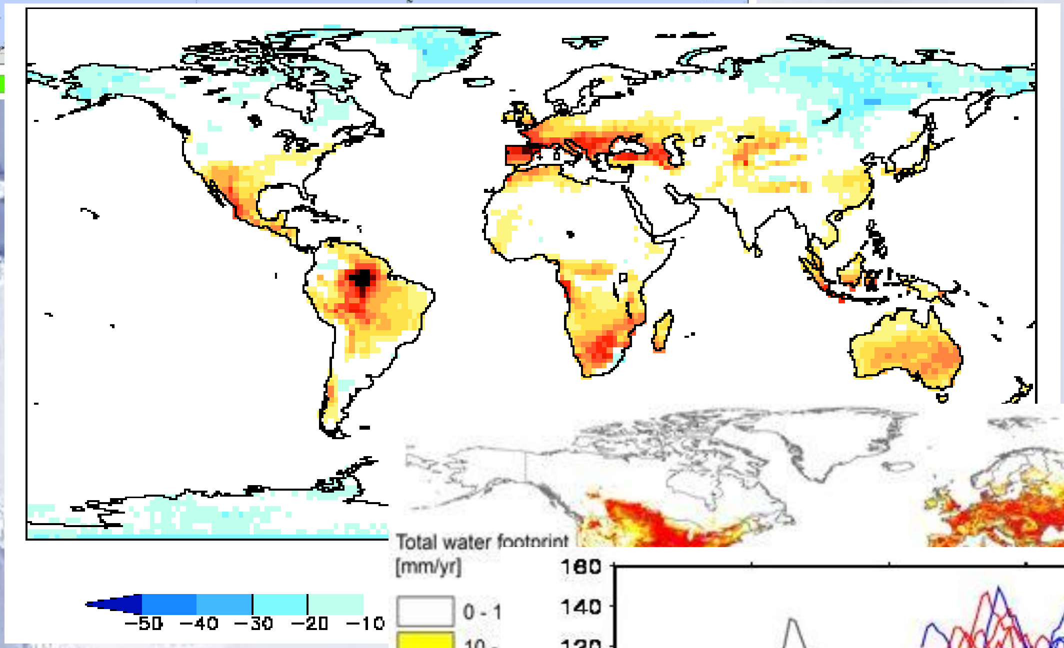
  Begins to tackle the issue of rigorous attribution of observed societal impacts to climate change (but not to *anthropogenic* climate change, specifically). Scientifically this is very immature.



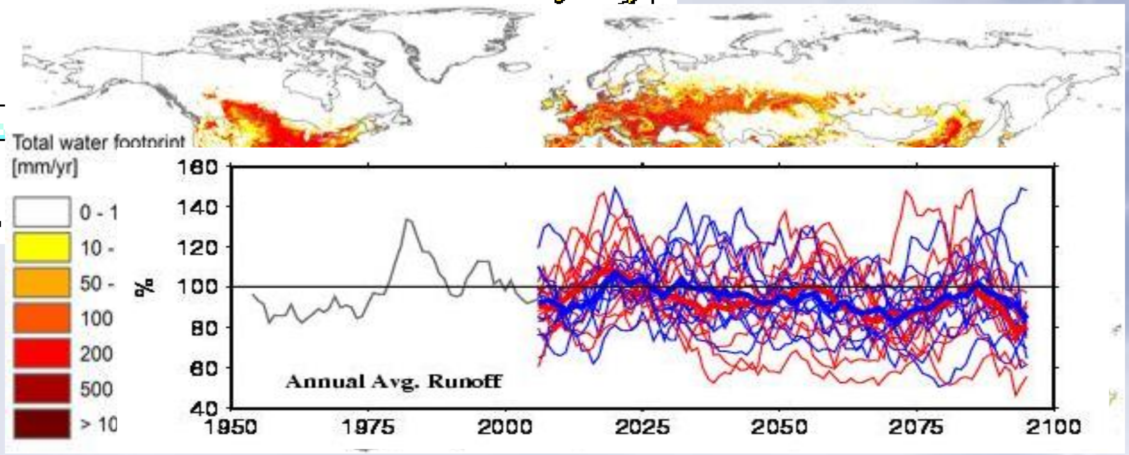
Ground water depletion



Model agreement (2050)



Water footprint



Many potential futures:

Adaptation requires science that analyzes decisions, identifies vulnerabilities, improves foresight, and develops options

Recent Studies of Mid-century Climate Change Impacts on Colorado River flows (Lee's Ferry)

The future is already here. It's just not very evenly distributed. -- William Gibson

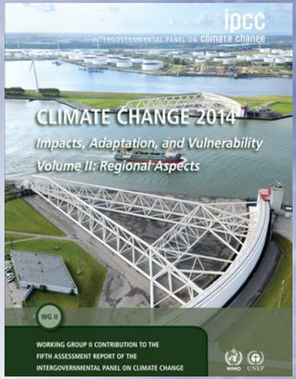
Recent Studies	**Projected Annual Flow Reductions**
Christensen et al., 2004	~18%
Christensen and Lettenmaier, 2007	~6%
Milly et al., 2005	10 to 25%
Hoerling and Eischeid, 2007	~45%
Seager et al., 2007	"an imminent transition to a more arid climate"
McCabe and Wolock, 2008	~17%
Barnett and Pierce, 2008	assumed 10-30%

Response One: These are so different, we can't trust any of them…

Response Two: We need to resolve these differences! Are the differences due to climate uncertainty or different models and methods?

Response Three: None of these studies show increasing flows. Any decrease is a source of concern.

Adaptation (Chapters 14-17)



14. Adaptation needs and options
15. Adaptation planning and implementation
16. Adaptation opportunities, constraints, and limits
17. Economics of adaptation

Chapters 14-17 include case studies from Least Developed Countries, indigenous peoples, and other vulnerable countries and groups

Multi-Sector Impacts, Risks, Vulnerabilities, and Opportunities (Chapters 18-20)

18. Detection and attribution of observed impacts
20. Climate-resilient pathways: adaptation, mitigation, and sustainable development (TW)

Highlighted statements Working Group II

Four adaptation chapters and two SPM sections

Actionable (If … Then …)	**Informative** (This is established / possible)	**Obvious** (Duh!)	**Potentially misleading** (Are you sure?)
x	x		
			x
		XXXXX	
X	XXXX	X	
	XXXXX x	XXXXX x	
x	X xx	XXX x	xx
2.0 (4%)	16.5 (40%)	22.0 (50%)	3.5 (7%)

Potential of enhancing the role of Local Govt and Private Sector

Increased awareness is often not translated into action

Adaptation is context specific

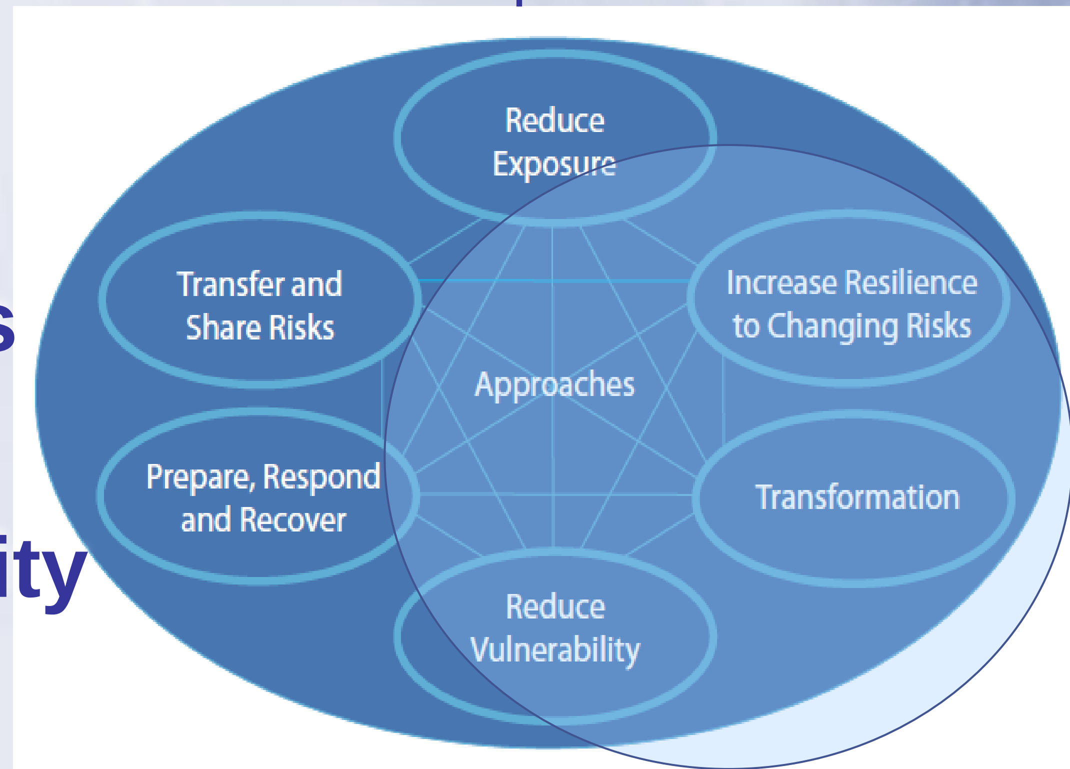
Adaptation is only beginning to move from awareness to planning

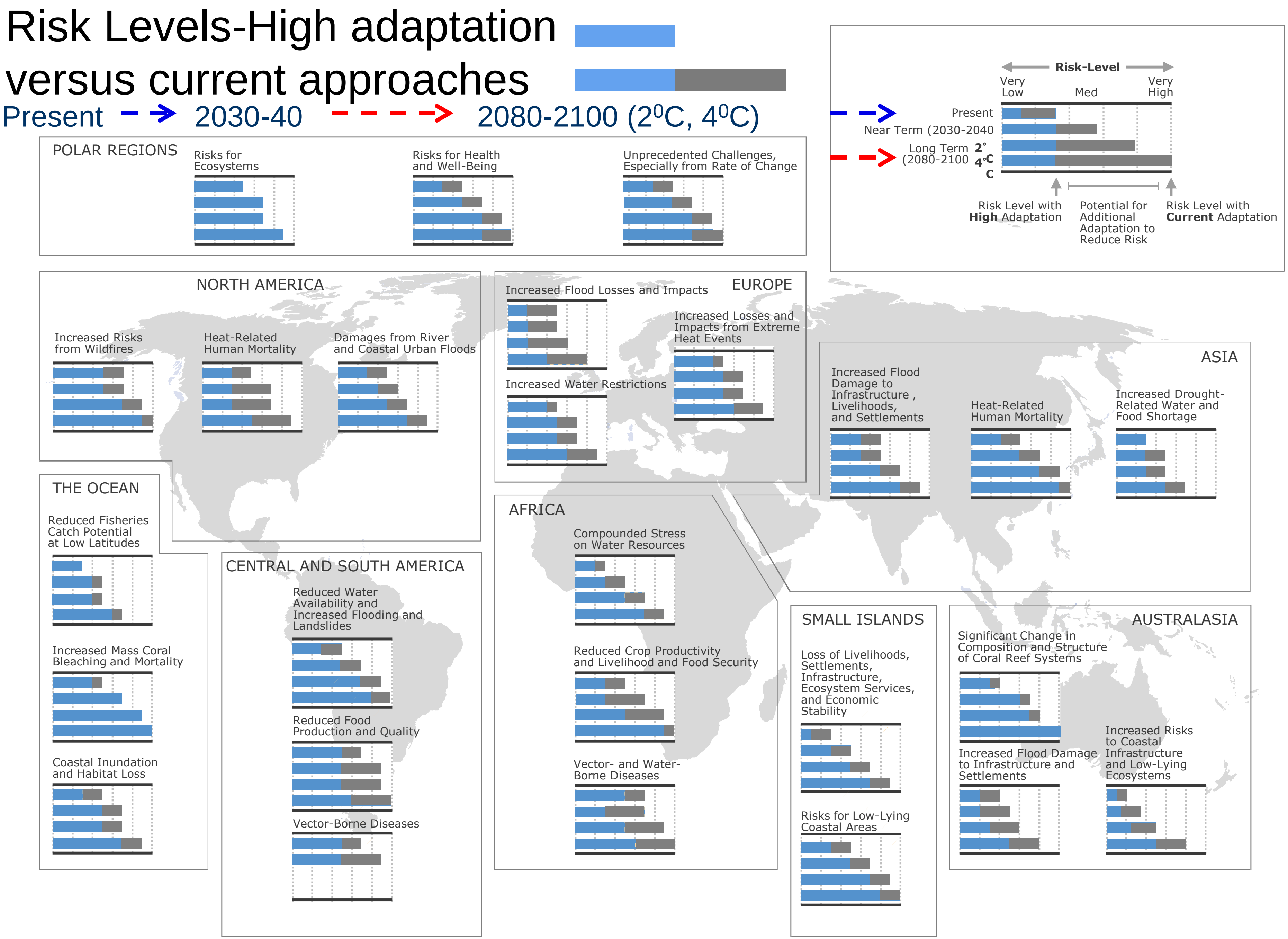
(Adapted from Noble, 2014)

Linking Preparedness and Adaptation

- **Information systems**
- **Infrastructure/technology**
- **Insurance**
- **Integrated systems**
- **Institutional capacity**

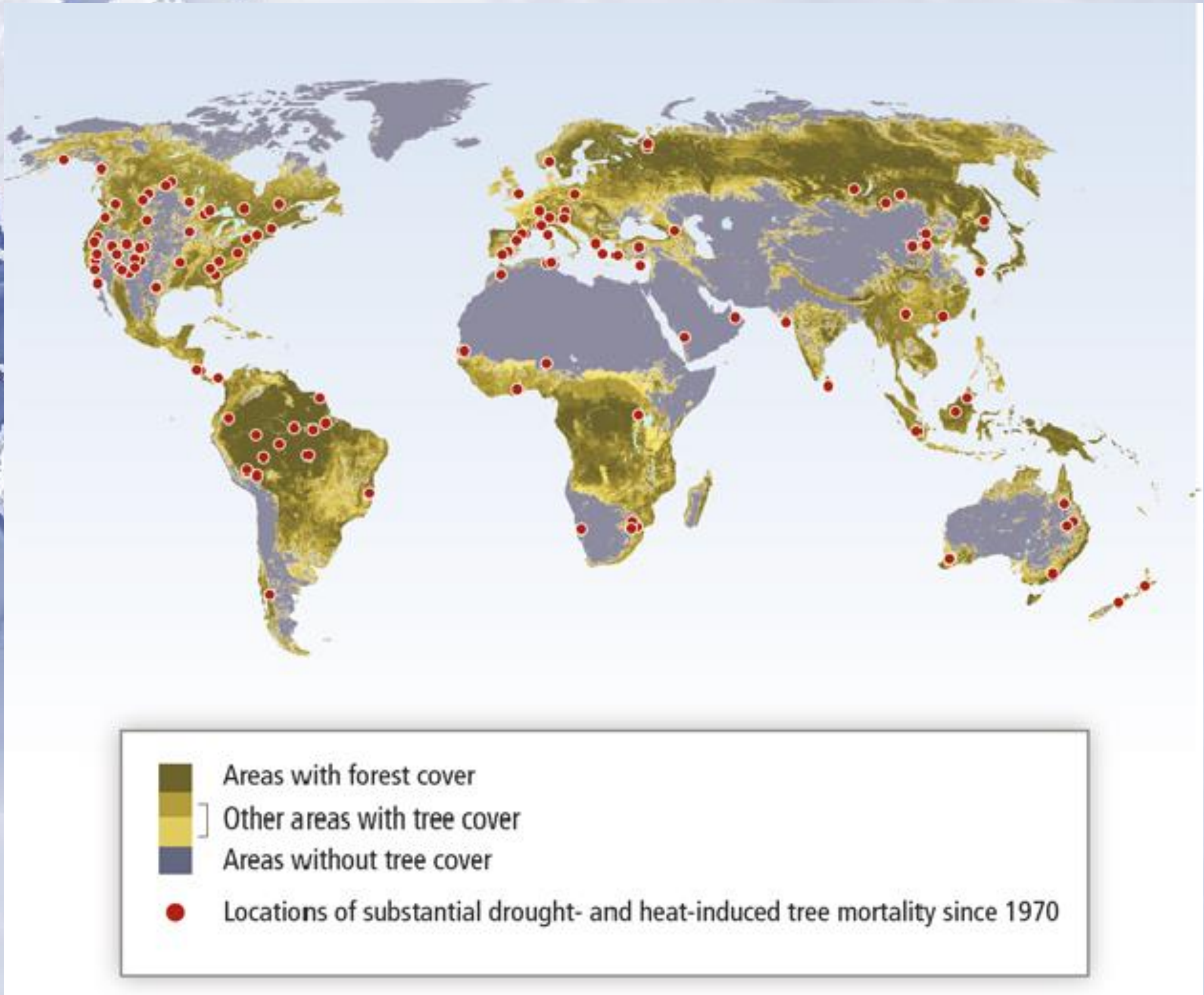
the Solution Space



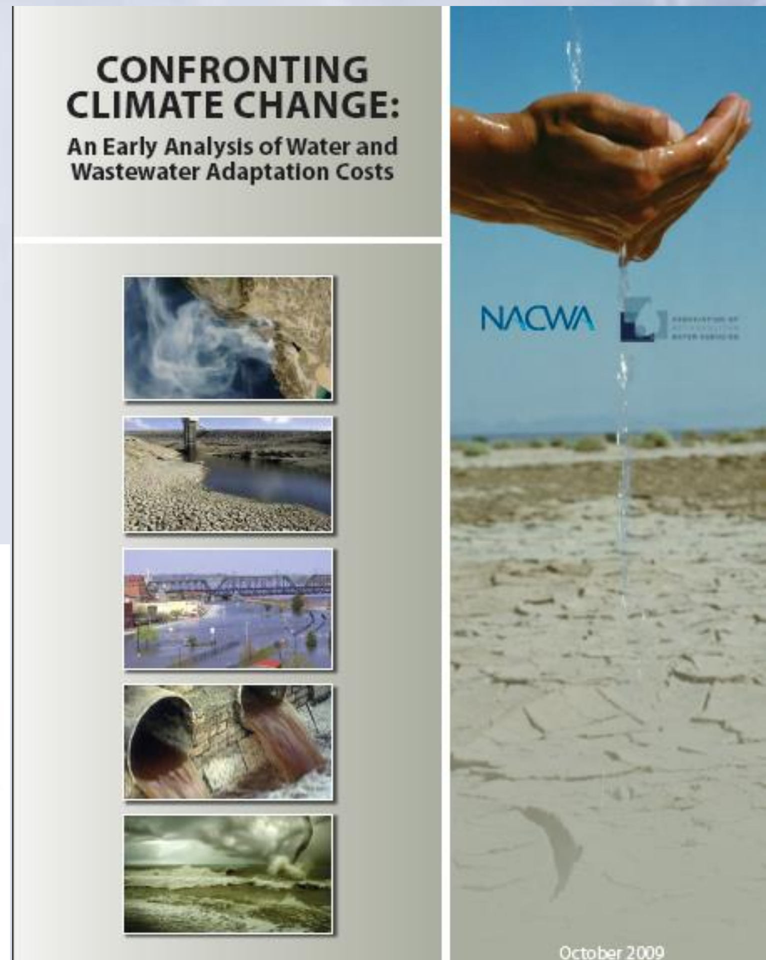

Risk Levels-High adaptation
versus current approaches
Present → 2030-40 → 2080-2100 (2⁰C, 4⁰C)
Risk-Level
Very Low
Med
Very High
Present
Near Term (2030-2040
Long Term (2080-2100
2°C
4°C
Risk Level with High Adaptation
Potential for Additional Adaptation to Reduce Risk
Risk Level with Current Adaptation
POLAR REGIONS
Risks for Ecosystems
Risks for Health and Well-Being
Unprecedented Challenges, Especially from Rate of Change
NORTH AMERICA
Increased Risks from Wildfires
Heat-Related Human Mortality
Damages from River and Coastal Urban Floods
EUROPE
Increased Flood Losses and Impacts
Increased Losses and Impacts from Extreme Heat Events
Increased Water Restrictions
ASIA
Increased Flood Damage to Infrastructure , Livelihoods, and Settlements
Heat-Related Human Mortality
Increased Drought-Related Water and Food Shortage
THE OCEAN
Reduced Fisheries Catch Potential at Low Latitudes
Increased Mass Coral Bleaching and Mortality
Coastal Inundation and Habitat Loss
CENTRAL AND SOUTH AMERICA
Reduced Water Availability and Increased Flooding and Landslides
Reduced Food Production and Quality
Vector-Borne Diseases
AFRICA
Compounded Stress on Water Resources
Reduced Crop Productivity and Livelihood and Food Security
Vector- and Water-Borne Diseases
SMALL ISLANDS
Loss of Livelihoods, Settlements, Infrastructure, Ecosystem Services, and Economic Stability
Risks for Low-Lying Coastal Areas
AUSTRALASIA
Significant Change in Composition and Structure of Coral Reef Systems
Increased Flood Damage to Infrastructure and Settlements
Increased Risks to Coastal Infrastructure and Low-Lying Ecosystems

(IPCC, 2014)

Locations of tree mortality induced by substantial drought and heat (1970-2011)



Assess "Build-out": Services provided, Avoided costs



NACWA, AMWA

The Stakes on Climate Change:

US Water and Clean Water Sector Only (WUCA, 2012)

2011-2031: Without Adaptation

Drinking Water
Infrastructure Investment

$335 Billion [1]

OR ***$1 Trillion*** ***through 2035*** [4]

Clean Water
Infrastructure Investment

$298 Billion [2]

By 2050: Potential Adaptation Costs

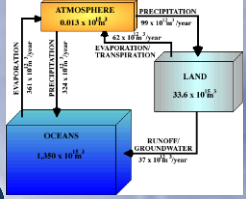
Drinking Water + Clean Water Sector:

$448 - 944 Billion [3]

[1] "2009 Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress." USEPA Office of Water, 2005.
[2] "Clean Watersheds Needs Survey 2008: Report to Congress." USEPA, May 2010.
[3] "Confronting Climate Change: An Early Analysis of Water and Wastewater Adaptation Costs," Association of Metropolitan Water Agencies, National Association of Clean Water Agencies, 2009.
[4] "Buried No Longer: Confronting America's Water Infrastructure Challenge, American Water Works Association, 2012.

Category of adaptation	Type of action	Examples
Addressing the adaptation deficit	Resilience building	■ Livelihood diversification to reduce poverty in context of climate variability ■ Crop insurance, seasonal forecasting, other agricultural innovation including irrigation ■ Early warning systems for DRR
Adapting to incremental changes	Climate proofing	■ Upgrading of drainage systems to accommodate greater runoff due to more intense of precipitation ■ Adapting cropping systems to shorter growing seasons, greater water stress and heat extremes (e.g. through crop substitution, irrigation, new strains) ■ Improving DRR systems to cope with more frequent and severe extremes
Adapting to qualitative changes	Transformational change	■ Phased relocation of settlements away from areas at existential risk from sea-level rise ■ Shifts in emphasis in large-scale economic activity away from areas/ resources threatened by climate change (e.g. away from water-intensive agriculture, climate-sensitive tourism, high-risk marine resources, to less sensitive activities) ■ Transformation of agricultural systems from unsustainable (under climate change) intensive rain-fed or irrigated agriculture to lower input e.g. pastoral or agropastoral systems.

Usually requested…..

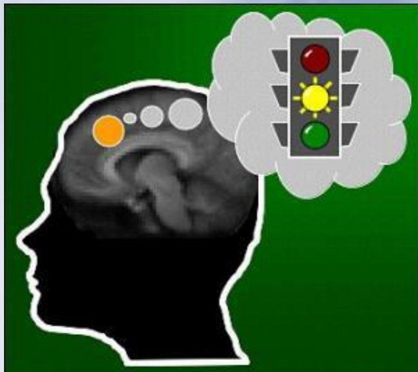


- **model agreement –convergence (not just at the grid-box scale)-**
- **narrowing the projection range**
- **higher-resolution spatial and temporal scales, and improved shorter**
- **time-horizon projections**

Influenced by choice of forcing data, calibration scheme, objective function etc.

The state of the practice is improving but in many cases does not fully recognize fundamental uncertainties – many studies are likely 'overconfident'

Climate information for risk and resilience

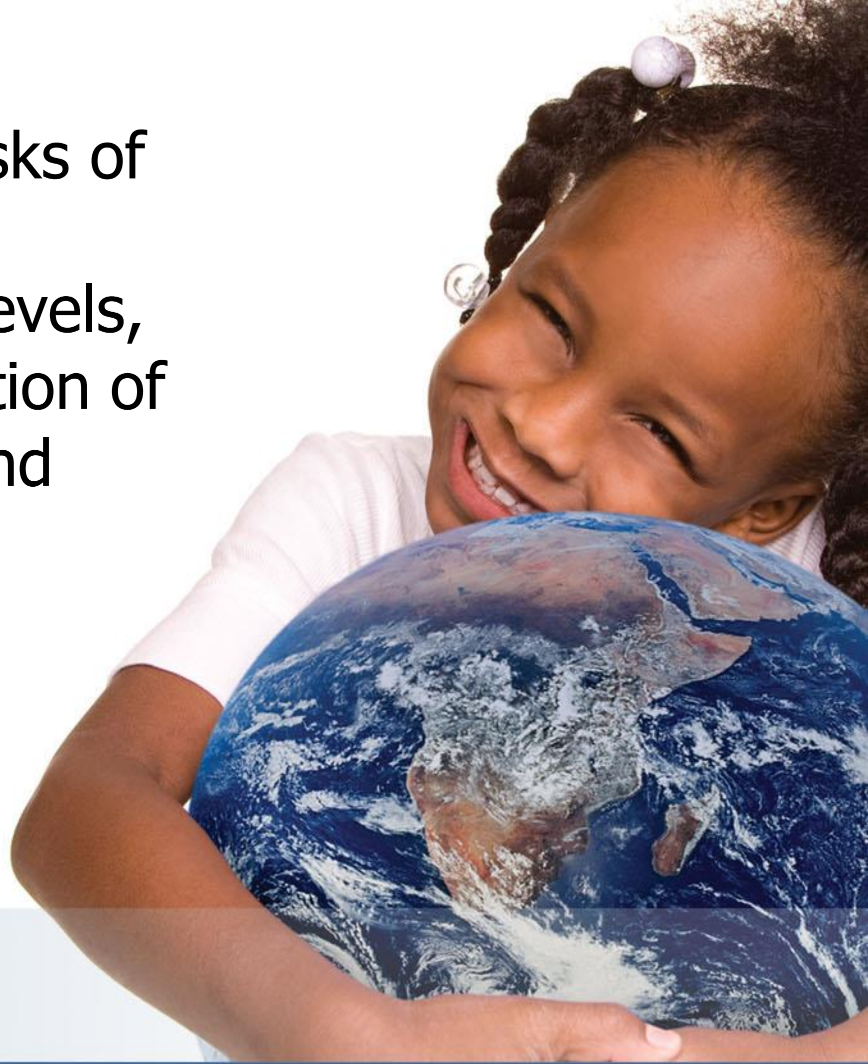


Strong risk of underestimating the complexity of adaptation

- Increasing recognition of adaptation buffers that arise from ecosystems, very little commensurate action to support this awareness

- Lack of coordination on implementation across the scales of governance with unclear division of tasks and responsibilities of actors, especially under conflicting timescales of interventions, and response

Enable better management of the risks of climate variability and change and adaptation to climate change at all levels, through development and incorporation of science-based climate information and prediction into planning, policy and practice.

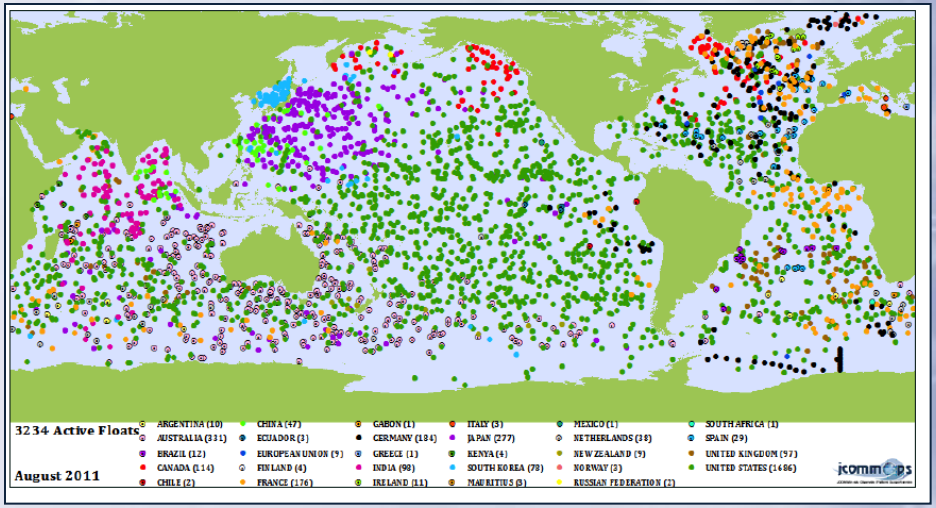


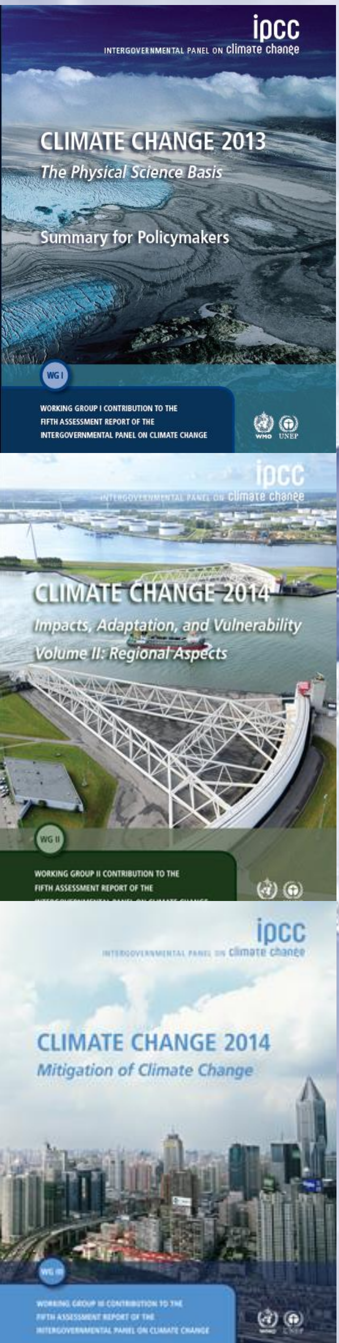
World Meteorological Organization
Weather • Climate • Water

Global Framework for Climate Services

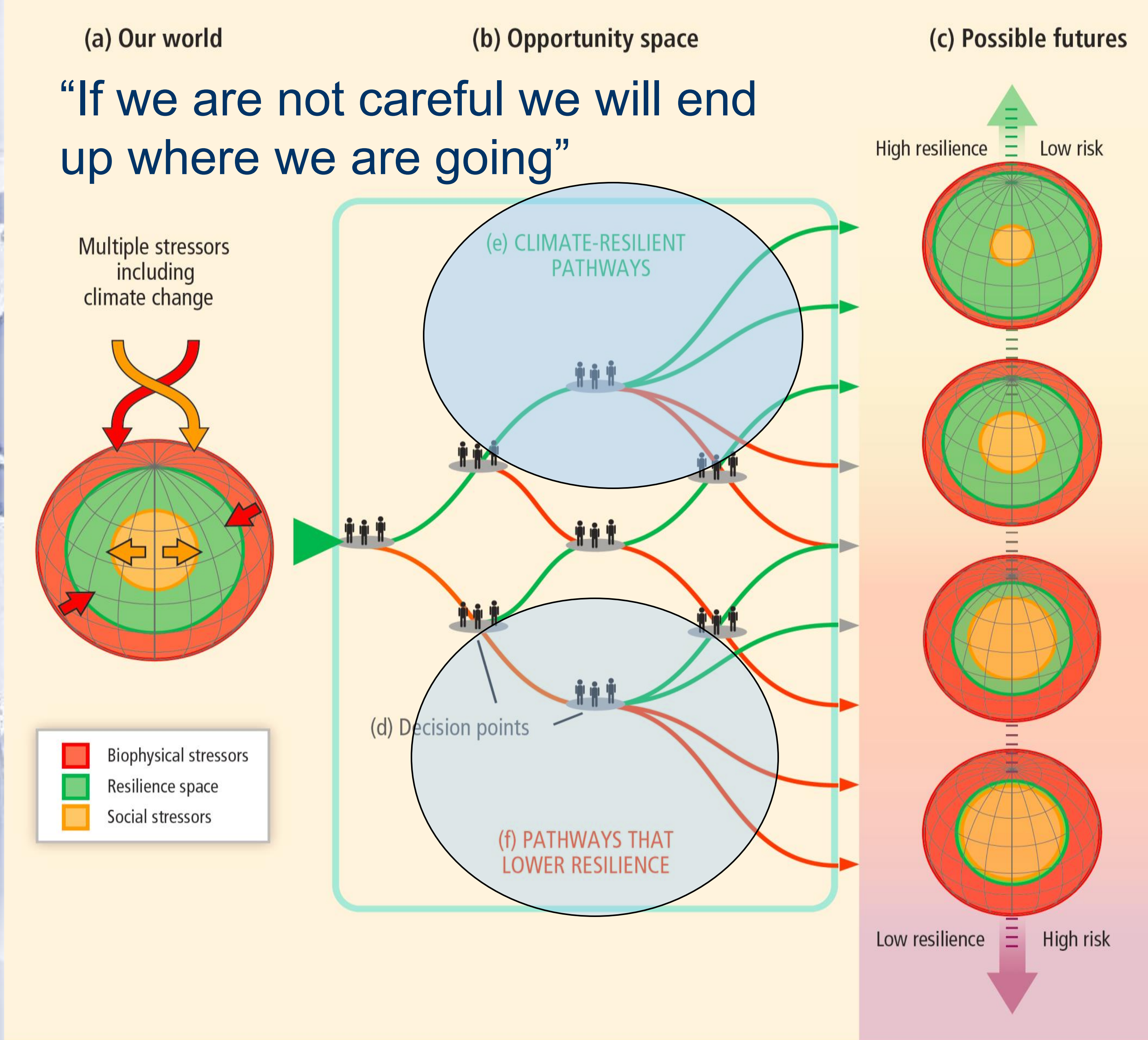
Observations and Monitoring: **the current availability and quality of climate observations and impacts data to support adaptation appear inadequate for large parts of the globe**

- Ocean
  - Global coverage
- Satellites
  - Weather and Climate
- Atmospheric
  - Global and domestic
- Capacity Building
  - WMO/IOC JCOMM Capacity Building Workshops
  - SERVIR
  - Global Climate Observing System (GCOS)





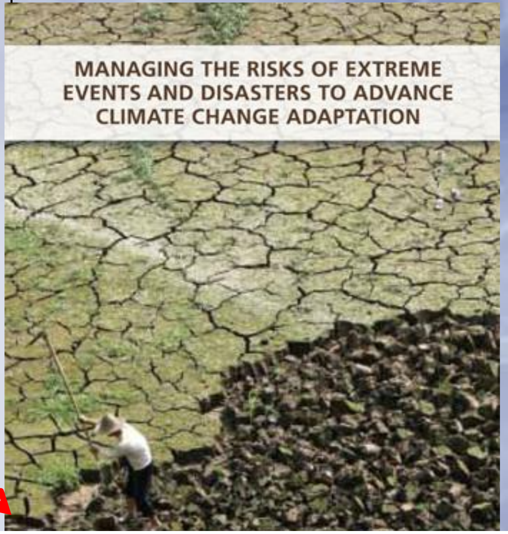
"If we are not careful we will end up where we are going"



'No or low regrets' practices with demonstrated evidence of having integrated observed trends in disaster risks to reduce the effects of disasters	Practices that enhance resilience to projected changes in disaster risk
• Effective early warning systems and emergency preparedness (*very high confidence*) • Integrated water resource management (*high confidence*) • Rehabilitation of degraded coastal and terrestrial ecosystems (*high confidence*) • Robust building codes and standards reflecting knowledge of current disaster risks (*high confidence*) • Ecosystem-based/nature-based investments, including ecosystem conservation measures (*high confi* • Micro-insurance, including weath indexed insurance (*medium confi* • Vulnerability-reducing measures s pro-poor economic and human development, through for exampl improved social services and prot employment, wealth creation (*ve confidence*)	• Integrated coastal zone management integrating projections of sea level risk and weather/climate extremes (*medium confidence*) • National water policy frameworks and water supply infrastructures, incorporating future climate extremes and demand projections (*medium-high*

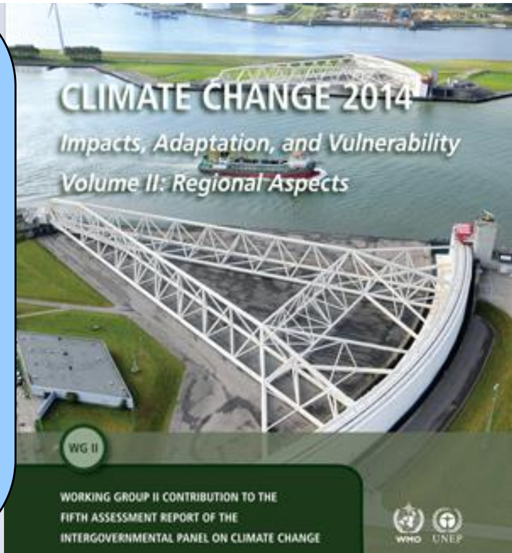
Effective early warning systems and emergency preparedness

Vulnerability reducing measures such as pro-poor economic and human development, through improved social services and protection



Anticipation

Resilience



Domain	GCOS Essential Climate Variables
Atmosphere (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapor, Pressure, Precipitation, Surface radiation budget. **Upper-air:**[2] Temperature, Wind speed and direction, Water vapor, Cloud properties, Earth radiation budget (including solar irradiance). **Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases[3], Ozone and Aerosol, supported by their precursors[4].
Ocean	**Surface:**[5] Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean color, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

[1] Including measurements at standardized, but globally varying heights in close proximity to the surface. [2] Up to the stratopause. [3] Including (N2O), (CFCs), (HCFCs), (HFCs), (SF6), and s (PFCs). [4] In particular (NO2), (SO2), (HCHO) and (CO). [5] Including measurements within the surface mixed layer, usually within the upper 15m.

Business concerns[1]

- Direct physical impacts on the investments themselves
- Degradation of critical supporting infrastructure
- Changes in the availability of key natural resources
- Changes to workforce availability or capacity
- Changes in the customer base
- Supply chain disruptions
- Legal liability
- Shifts in the regulatory environment
- Reductions in credit ratings

1: AMS, 2014: Climate Information Needs for Financial Decision Making

Developing Climate Risk Profiles

Vulnerable Sector/ activity/ group	Magnitude	Rates of Change	Persistence and reversibility	Likelihood and confidence	Distribution	Potential for Adaptation
Economic sectors (Water, Ag, Tourism etc.) Communities at risk Bounded ecosystems such as coastal, mountain, semi-arid zones already stressed	Levels of vulnerability Different magnitudes of change, especially thresholds, relative to temp& precip. and other critical parameters	Critical rates/ threshold Steeper response curves that affect vulnerabi lity	Likelihood that the vulnerable sector will be affected by an irreversible impact and persistence	Overall confidence and likelihood State confidence with a measure of ignorance/ indeterminacy	Distribution of impacts Both physical and social within countries (not in a simple developed/ developing dichotomy).	Capacity for adaptation Is adaptive capacity sufficient to delay or prevent adverse impacts and at what cost.

WGII &Leggett and Pulwarty

Monitoring and Forecasts

Understanding how decadal variability in different ocean basins impact year to year droughts-influences forecast reliability on seasonal to interannual timescales, global monitoring

Improved satellite estimates and in situ measurements of soil moisture and developing coordinated soil moisture networks

Estimates of Ground water/surface water interactions during drought especially affecting streamflow and river forecasts

Ongoing assessment of the underlying predictability of surface temperature, precipitation, soil moisture, and streamflow affected by climate, land-use and demands on monthly to decadal time scales

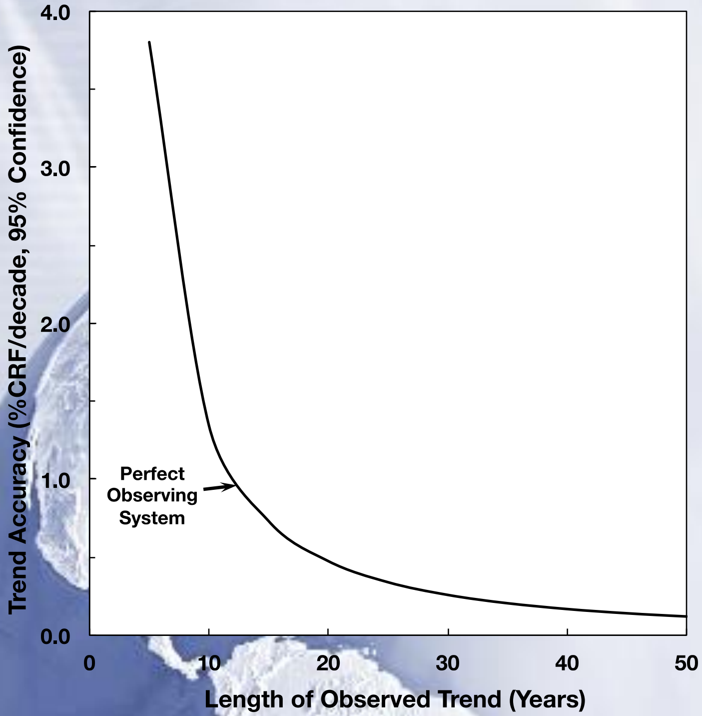
Analysis of significant past events/cases

Sources of investment and financial flows

Private sources of funding can be expected to cover a portion of the adaptation costs in several sectors. In particular in the Infrastructure sector where investment in privately own physical assets would be needed

However, ***public resources are expected to play a predominant role in all adaptation sectors***

National measures needed to incentivize private sector adaptation, AND for additional resources dedicated to adaptation that meet cross-sectoral public needs



The length of time required to detect a climate trend caused by human activities is determined by:

- ***Natural variability***
- ***The magnitude of human driven climate change***
- ***The accuracy of the observing system***

The year in which we become 90% certain depends on our Earth observations, their accuracy, and their completeness. The economic value of advanced climate observing systems is dramatically larger than their cost

(Wielicki et al, 2013)

We lack a comprehensive climate observing system capable of testing climate predictions with sufficient accuracy or completeness

The relationship between public and private monitoring and research is not linear

- More than the simple costless transfer of basic knowledge from publicly-funded institutions to profit-oriented firms
- Ability to access and interact with federal sector research activity is an important determinant of the productivity of downstream state and private sector research
- Participating in this exchange can be an important determinant of private sector research productivity
- This works both ways

Is the contribution of geospatial information to innovation and competitiveness quantifiable and how would it be done ?

Economics group looked at overall priorities (GEO,NCAR, June 2012)

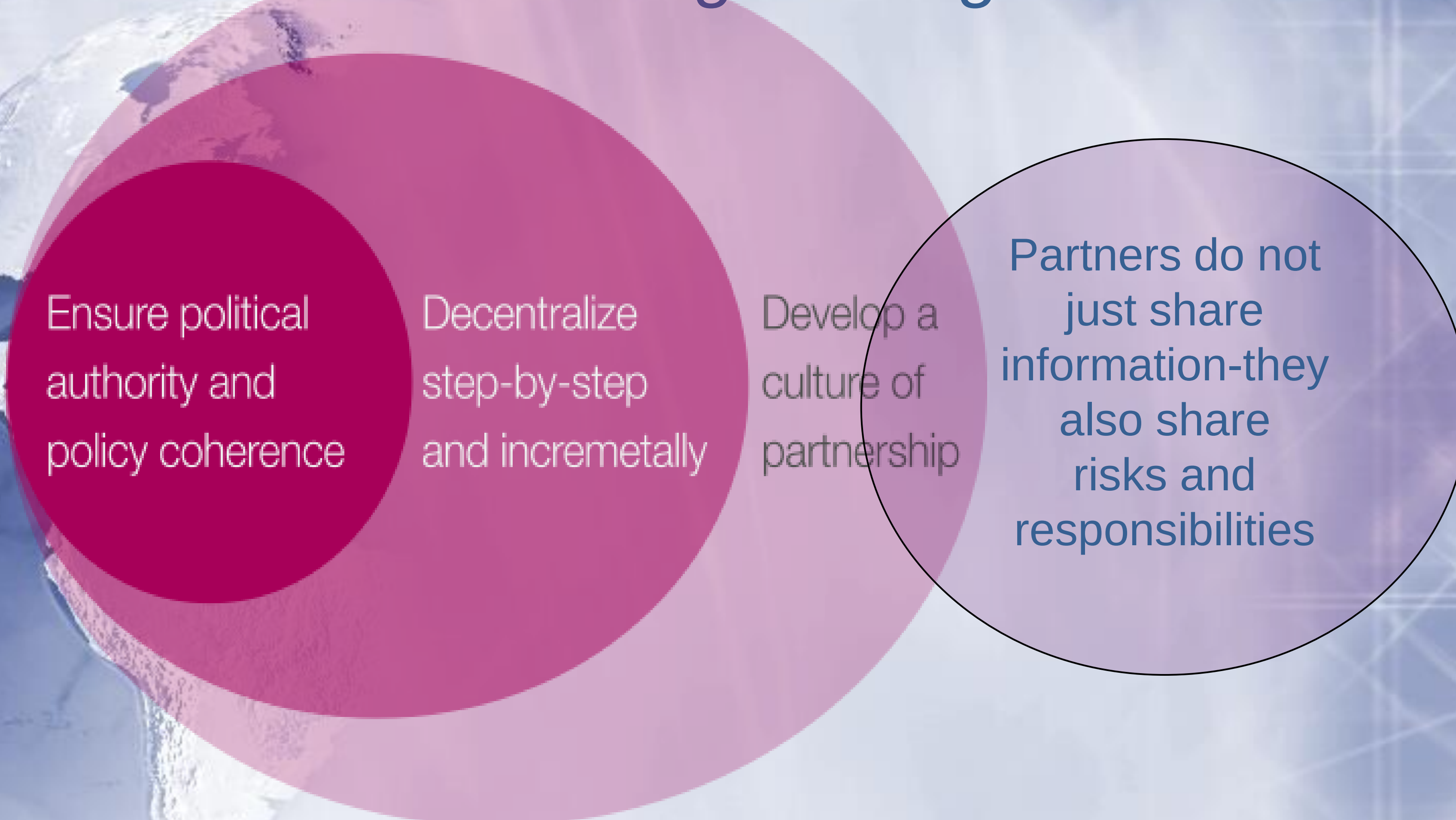
Six people had $2 each, and voted on where to spend his/her money.

Result:

Open Access to Data $$;
Other Non-Financial Measures of Value $;
Interdisciplinary Approach $$$$;

Prototype Case Studies $$$$$

Sustaining "services" Climate risk management governance



Accountability- located with planning/fiscal oversight- political authority and policy coherence across sectors

Efficiency- achieved in partnership with at-risk sectors and local communities and organizations that represent them-

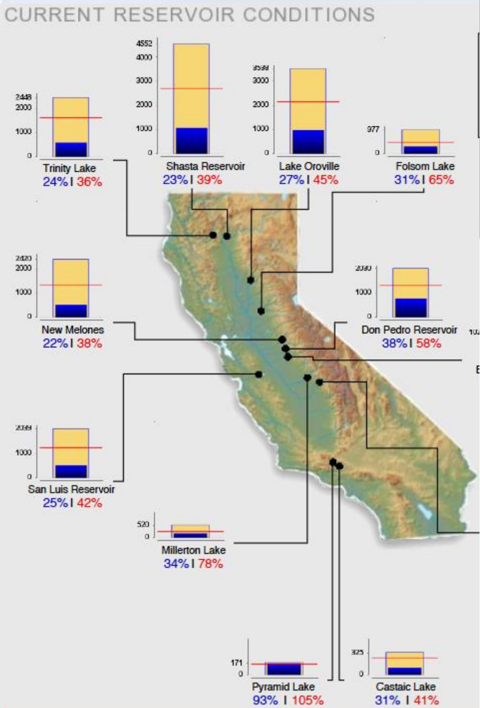
Question: What are/ought to be the roles of the IAV (Impacts, Adaptation and Vulnerability) research community, development programmes, and public and private climate services in helping to secure and sustain coordinated global climate observational networks?

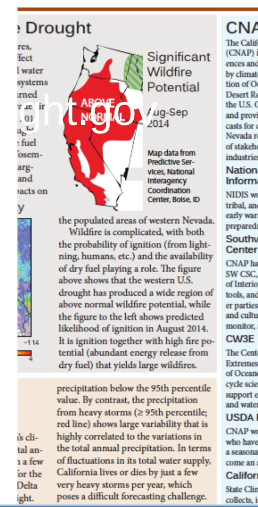
Challenge Develop integrated observation and modeling systems that address the needs of vulnerable sectors, resources, and investment strategies.

•Major challenges- designing observational systems, defining ECVs, conducting and communication analyses that characterize changing rates and transitions

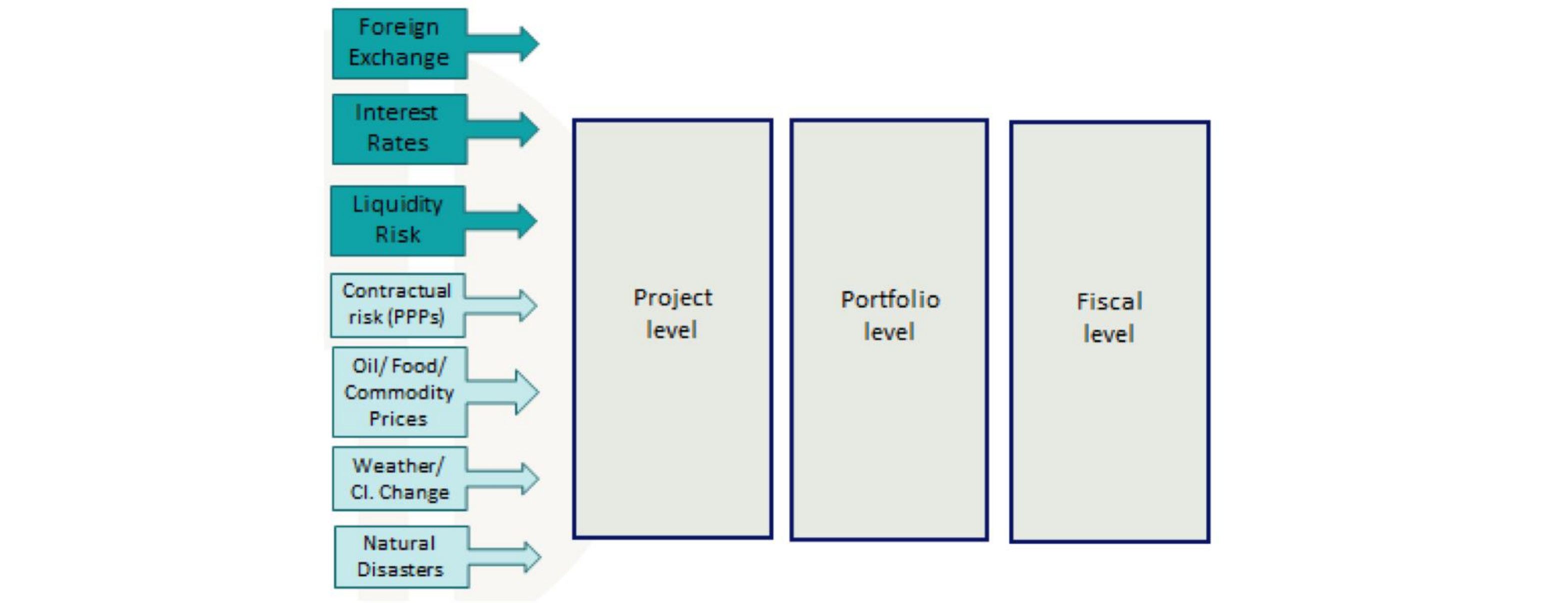
•Understand how new information relates to what is already known and how often should adaptation decisions be reconsidered (i.e. informing “smart” vs. “best” practices”)

Thank you.





Coordination



Opportunities exist for synergies in international finance for disaster risk management and adaptation that produce co-benefits, but these have not yet been fully realized-

Governments and private sectors want to be able to answer questions such as:

> *How should we compare the marginal benefits of expenditures for infrastructure investments, price hedging instruments, insurance programs, catastrophe reconstruction bonds, or building retro-fitting? for near-term vs. long-term risks?*

Integrated Risk Management in Latin America 2014 (Brandon, World Bank, 2014)

Sustaining a collaborative framework among observations, research and management –multiple adaptation options and practice

•Does the present data collection cover current observational requirements and potential requirements for understanding impacts under a changing climate?

•Does current monitoring provide moving baselines for assessing effectiveness of response and adaptation measures?

•Despite the extensive development and use of indicators, there is little testing of these indicators to assure that they indeed provide the assumed positive information benefit.

Major themes of the WG2 contribution to AR5:

1) *Integration of climate science with impacts*

2) *Broad range of assessed impacts*

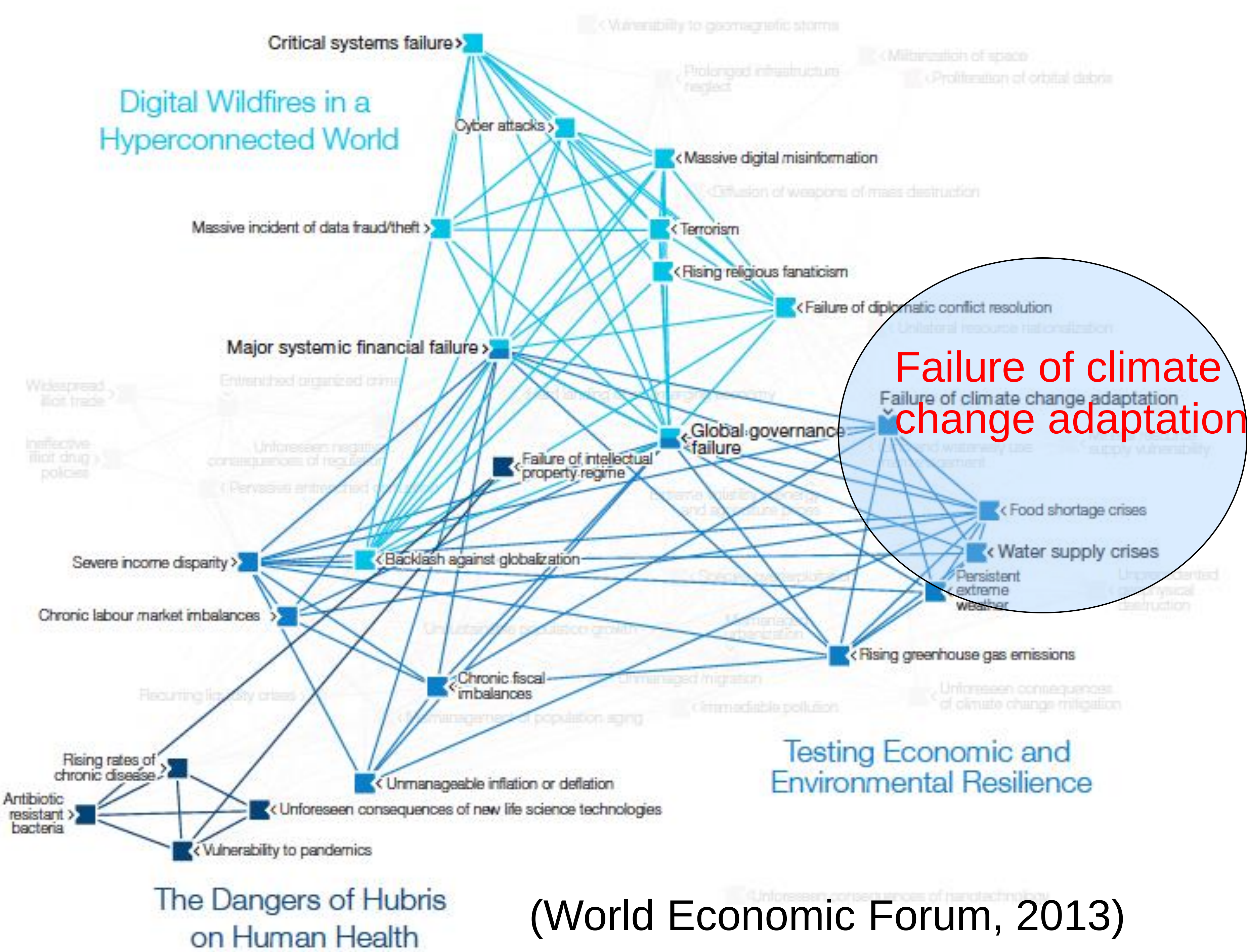
3) *Assessing impacts of climate change in the context of other stresses*

4) *Support for good policy decisions*

5) *Expanded coverage of adaptation*

6) *Integration of adaptation mitigation, development and sustainability*

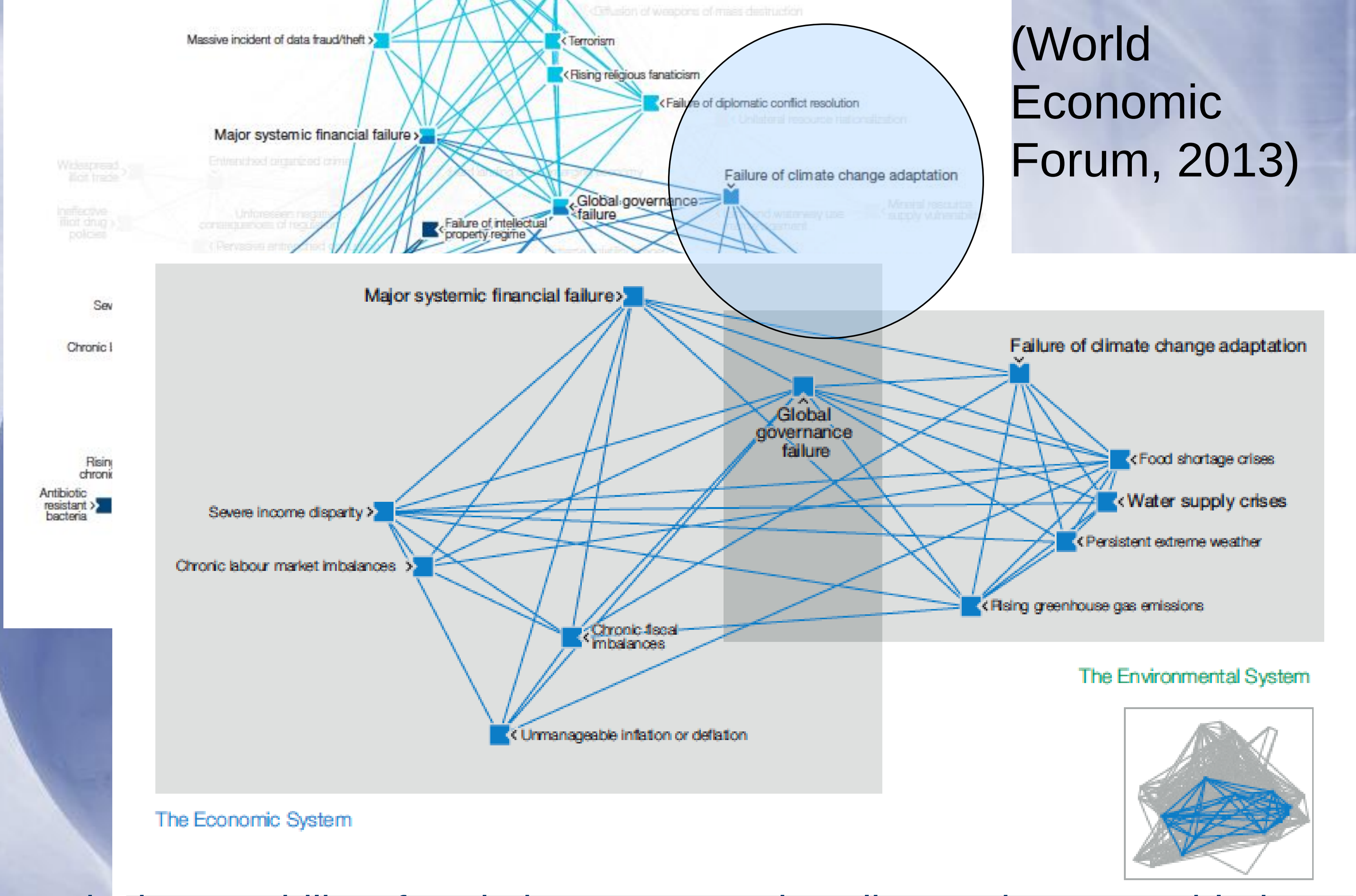
7) *More comprehensive treatment of regional aspects, with input from WGs I and III*



Failure of climate change adaptation

(World Economic Forum, 2013)

(World Economic Forum, 2013)



How is the capability of societies to respond to climate change enabled or constrained by other social, ecological and political dynamics?

How can improved climate services help to deal with these interconnected dynamics?

Let's Not Wait too long!

THANK YOU!

Monitoring for extremes in the context of change:

Risks to investments "capitals" (World Bank, 2012; Hallegatte 2012)

Potential benefits from upgrading to developed-country standards hydro-meteorological information and early warning capacity in all developing countries include:

•Between 300 million and 2 billion USD per year of avoided asset losses due to natural hazards
•Between 3 and 30 billion USD per year of additional economic benefits.

The total benefits would reach between 4 and 36 billion USD per year. Benefit-cost ratios between 4 and 35 with co-benefits