The mind's eye of international policy making in a complex climate

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LSE COMPLEXITY research seminar

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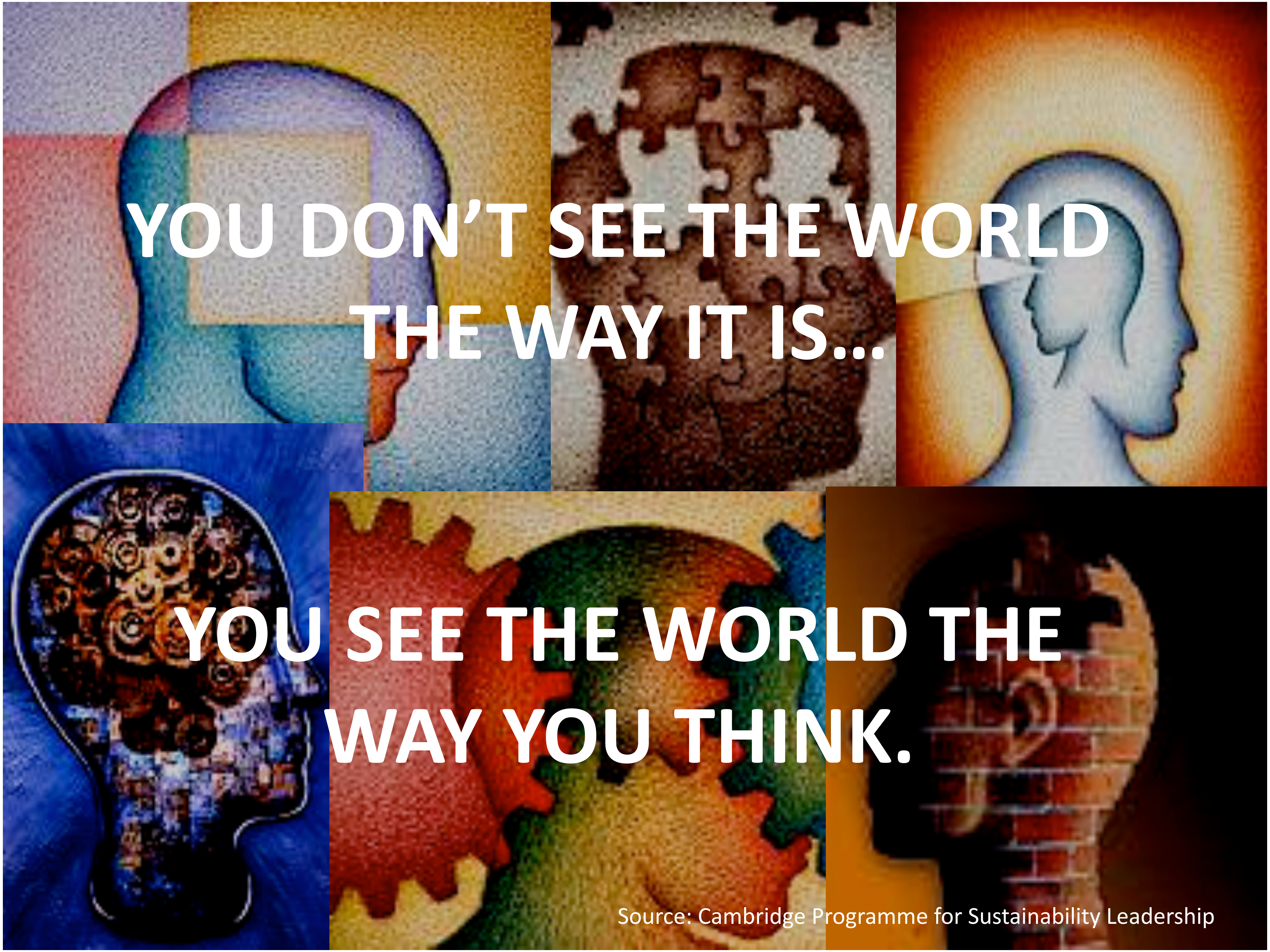
The Open University

ESRC Complexity Research Seminar Series, Seminar 2

Applied Complexity Theory as the New Framework for Management and Public Policy

Energy & Climate Change: the Contribution of Complexity Science

9:30 - 18:00, 24th March 2009, London School of Economics


YOU DON'T SEE THE WORLD THE WAY IT IS...
YOU SEE THE WORLD THE WAY YOU THINK.
Source: Cambridge Programme for Sustainability Leadership

By 2030 the demand for resources will create a crisis with dire consequences, Prof John Beddington said.

Water shortages are predicted across large parts of Africa, Europe and Asia

Demand for food and energy will jump 50% by 2030 and for fresh water by 30%, as the population tops 8.3 billion, he told a conference in London.

Climate change will exacerbate matters in unpredictable ways, he added.

'Complacent'

"It's a perfect storm," Prof Beddington told the Sustainable Development UK 09 conference.

"There's not going to be a complete collapse, but things will start getting really worrying if we don't tackle these problems."

'Perfect storm' poses global threat, says Professor Beddington

Prof Beddington said the looming crisis would match the current one in the banking sector.

"My main concern is what will happen internationally, there will be food and water shortages," he said.

http://news.bbc.co.uk/1/hi/uk/7951838.stm. 19th March 2009

THE ICEBEG OF REALITY

EVENTS……………REACTIVE

PATTERNS………..ADAPTIVE

SYSTEMIC
STRUCTURES…….CREATIVE

MENTAL MODELS…………
REFLECTIVE

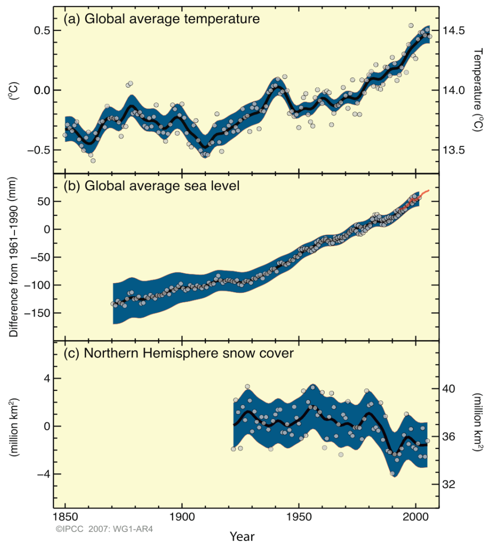
WORLDVIEWS……GENERATIVE

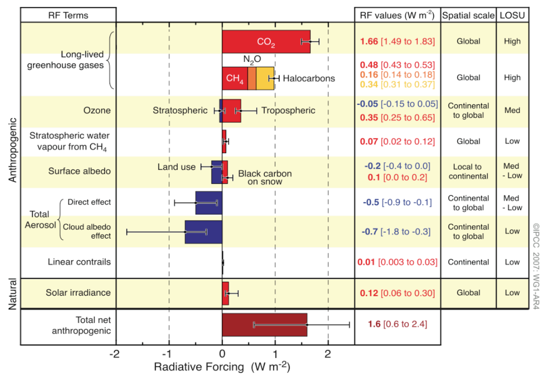
Source: Cambridge Programme for Sustainability Leadership

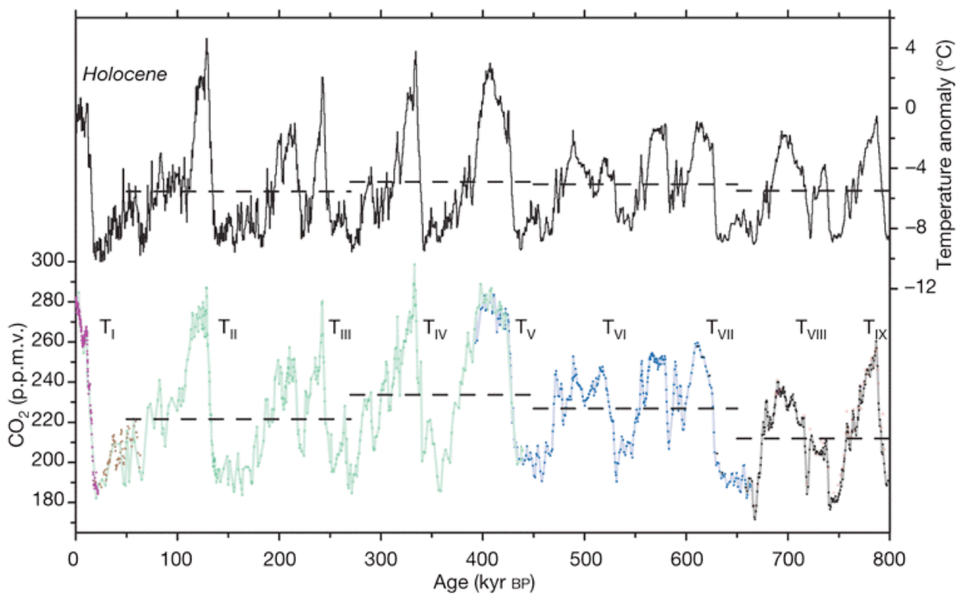
The mind's eye of international policy making

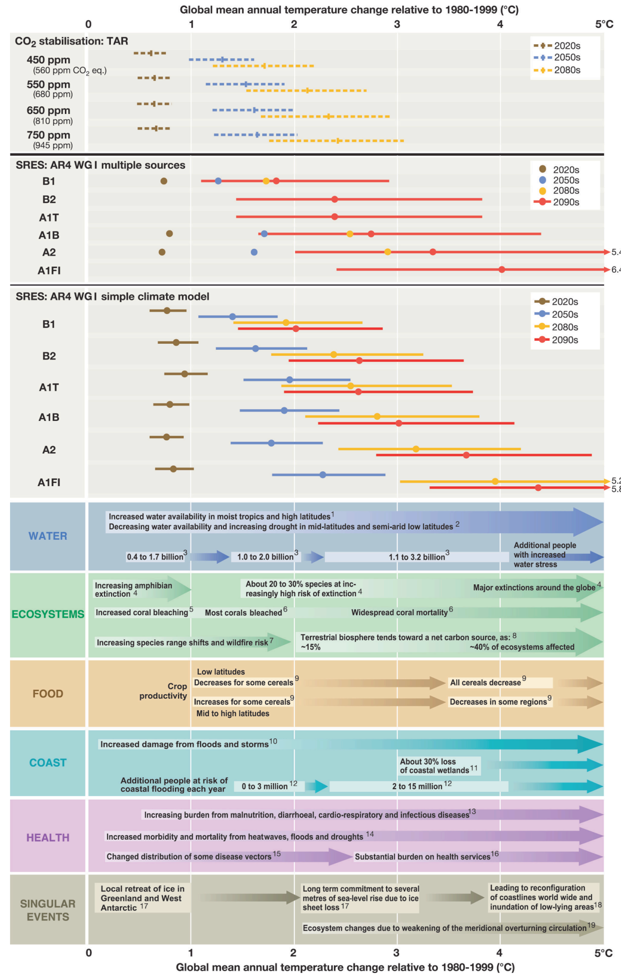
- What is happening? – science, policy analysis
- What is necessary? – science, risk analysis
- What is possible? – physics, economics, technology
- What is fair? – policy analysis, modelling, ethics
- What is achievable? - politics

WHAT IS HAPPENING?



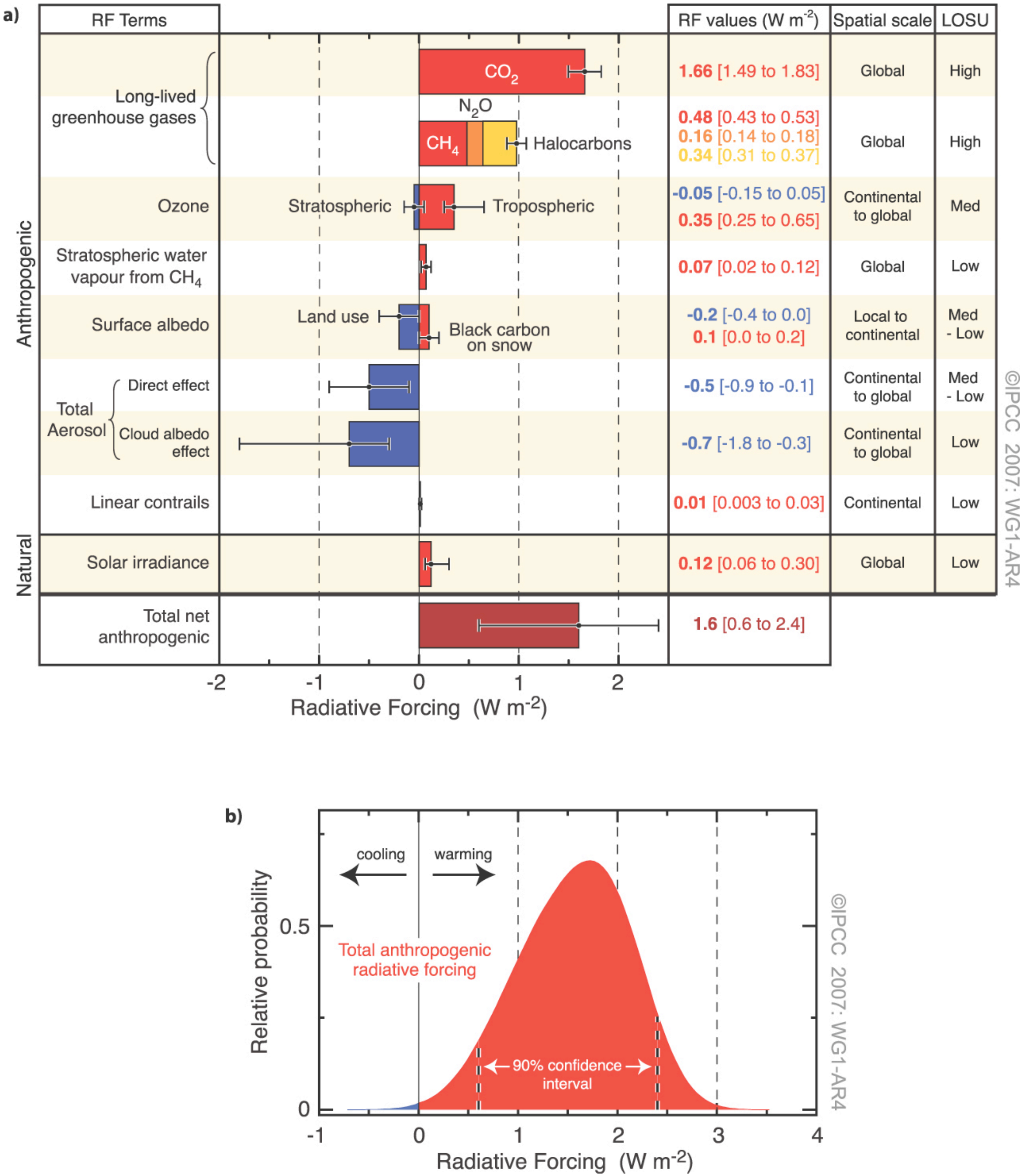






Very high confidence

- Discernible impacts on many physical and biological systems
- Spring is getting earlier (leaf budding, bird migration, egg laying
- Poleward and upward shifts in ranges in plant and animal species
- Ocean is more acidic with an av. Decrease in pH of 0.1 units


a)
RF Terms
RF values (W m-2)
Spatial scale
LOSU
Anthropogenic
Long-lived greenhouse gases
CO2
1.66 [1.49 to 1.83]
Global
High
N2O
CH4
Halocarbons
0.48 [0.43 to 0.53]
0.16 [0.14 to 0.18]
0.34 [0.31 to 0.37]
Global
High
Ozone
Stratospheric
Tropospheric
-0.05 [-0.15 to 0.05]
0.35 [0.25 to 0.65]
Continental to global
Med
Stratospheric water vapour from CH4
0.07 [0.02 to 0.12]
Global
Low
Surface albedo
Land use
Black carbon on snow
-0.2 [-0.4 to 0.0]
0.1 [0.0 to 0.2]
Local to continental
Med - Low
Total Aerosol
Direct effect
-0.5 [-0.9 to -0.1]
Continental to global
Med - Low
Cloud albedo effect
-0.7 [-1.8 to -0.3]
Continental to global
Low
Linear contrails
0.01 [0.003 to 0.03]
Continental
Low
Natural
Solar irradiance
0.12 [0.06 to 0.30]
Global
Low
Total net anthropogenic
1.6 [0.6 to 2.4]
-2
-1
0
1
2
Radiative Forcing (W m-2)
©IPCC 2007: WG1-AR4
b)
cooling
warming
Relative probability
0.5
0
Total anthropogenic radiative forcing
90% confidence interval
-1
0
1
2
3
4
Radiative Forcing (W m-2)
©IPCC 2007: WG1-AR4

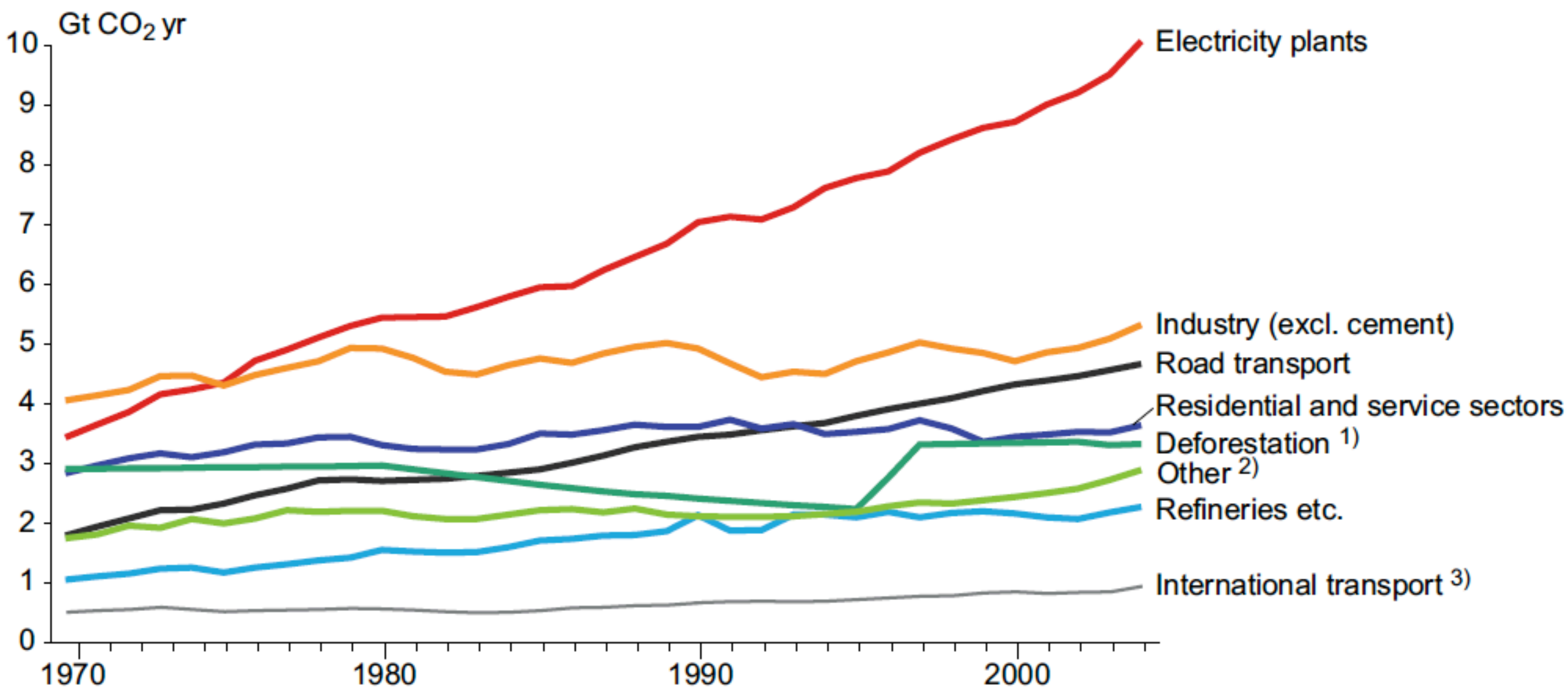


Figure 1.2: *Sources of global CO_2 emissions, 1970–2004 (only direct emissions by sector).*

1) Including fuelwood at 10% net contribution. For large-scale biomass burning, averaged data for 1997–2002 are based on the Global Fire Emissions Database satellite data (van der Werf *et al.*, 2003). Including decomposition and peat fires (Hooijer et al., 2006). Excluding fossil fuel fires.

2) Other domestic surface transport, non-energetic use of fuels, cement production and venting/flaring of gas from oil production.

3) Including aviation and marine transport.

Source: Adapted from Olivier et al., 2005; 2006).

Unpacking the drivers of growth

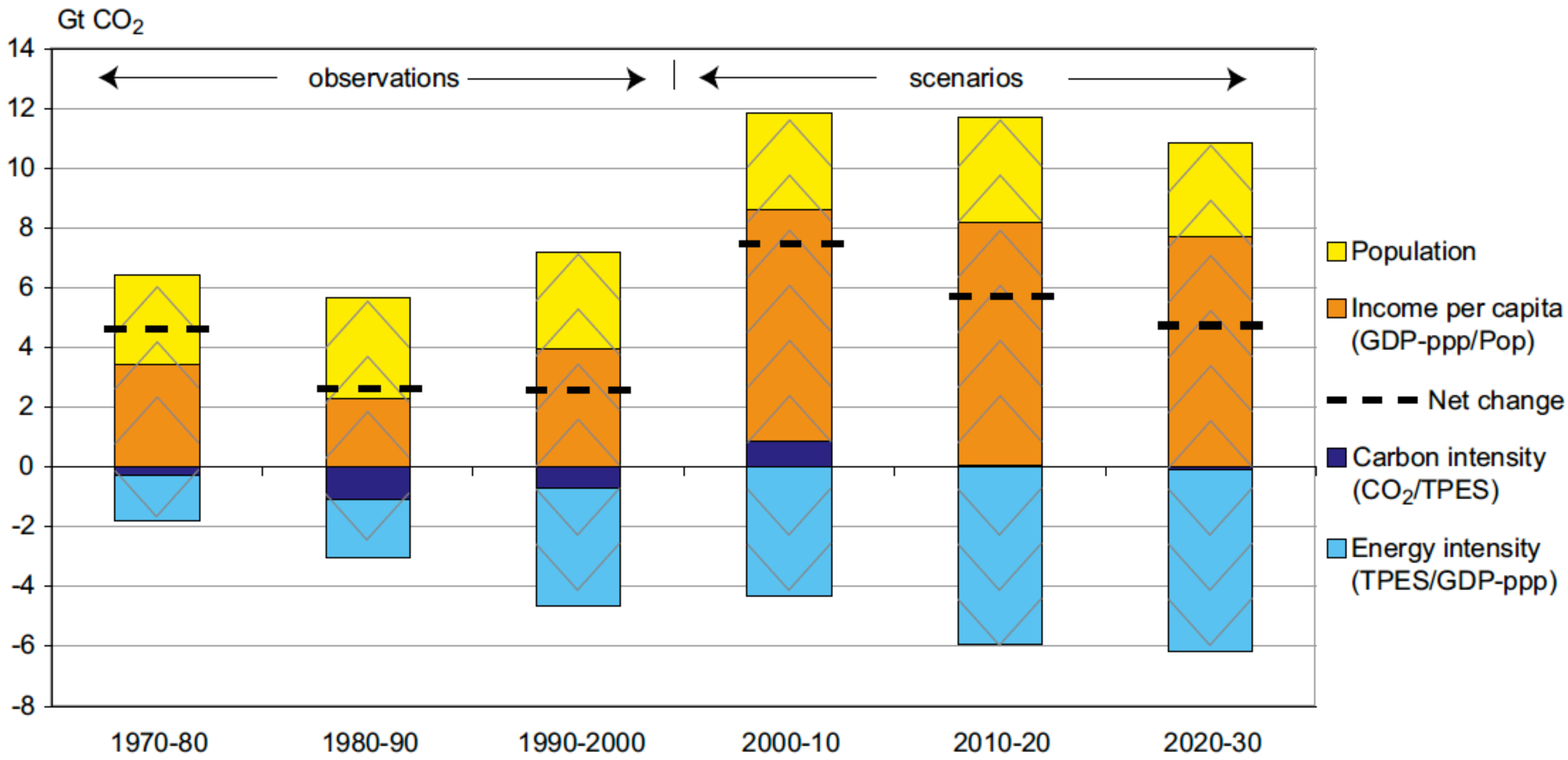


Figure TS.3: *Decomposition of global energy-related CO_2 emission changes at the global scale for three past and three future decades [Figure 1.6].*

WHAT IS NECESSARY?

Show WG1 diagram

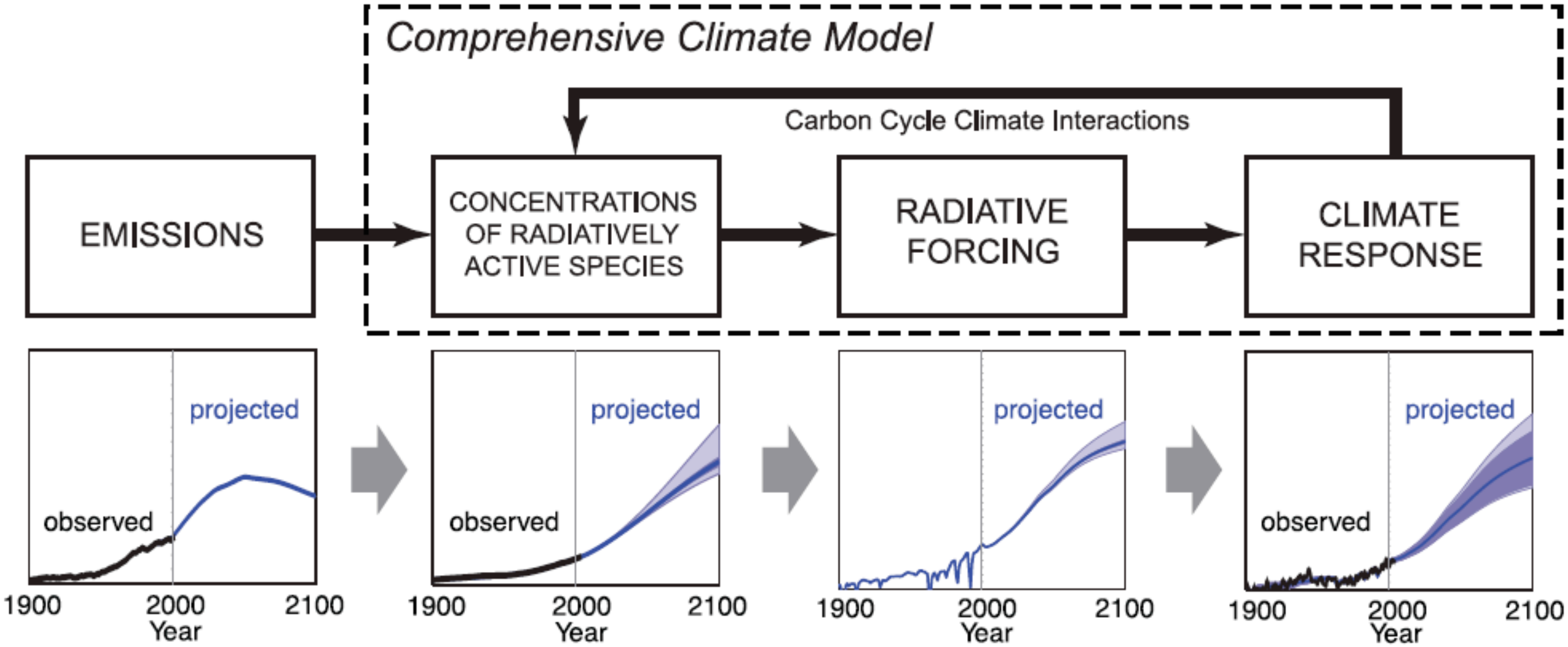


Figure 10.1. *Several steps from emissions to climate response contribute to the overall uncertainty of a climate model projection. These uncertainties can be quantified through a combined effort of observation, process understanding, a hierarchy of climate models, and ensemble simulations. In a comprehensive climate model, physical and chemical representations of processes permit a consistent quantification of uncertainty. Note that the uncertainty associated with the future emission path is of an entirely different nature and not addressed in Chapter 10. Bottom row adapted from Figure 10.26, A1B scenario, for illustration only.*

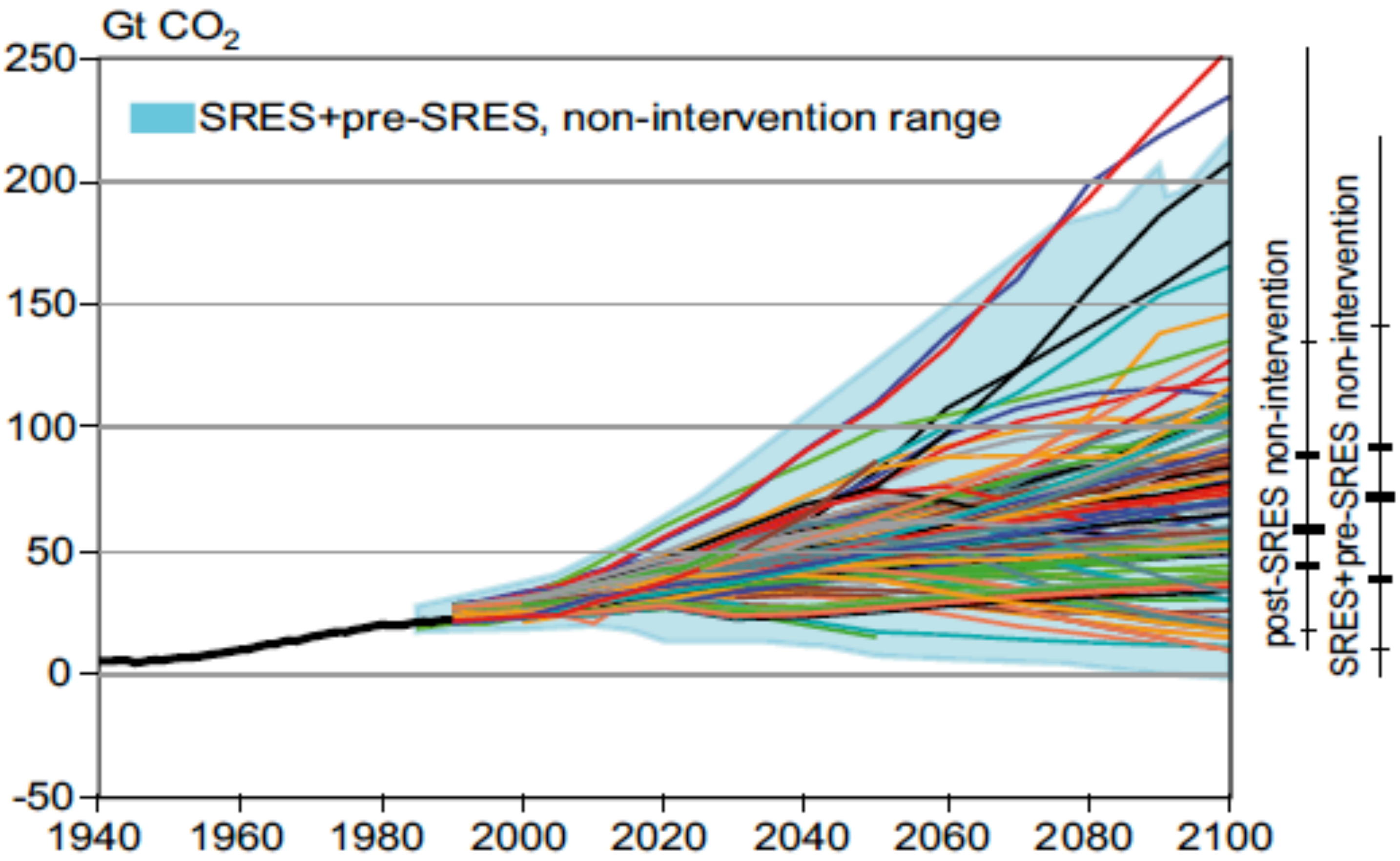


Figure TS.7: *Comparison of the SRES and pre-SRES energy-related and industrial CO_2 emission scenarios in the literature with the post-SRES scenarios [Figure 3.8].*

Note: Two vertical bars on the right extend from the minimum to maximum of the distribution of scenarios and indicate the 5th, 25th, 50th, 75th and the 95th percentiles of the distributions by 2100.

emissions scenarios are problematic

- The ranges over which driving forces vary are large…of these … GDP and population are often exogenous…(IPCC SRES, p100)
- Integrated scenarios. There are shortcomings in how interactions between key drivers of change are represented in scenarios. Moreover, socio-economic and technological scenarios need to account for the costs and other ancillary effects of both mitigation and adaptation actions, which at present are rarely considered. (IPCC AR4, WGII: p162)

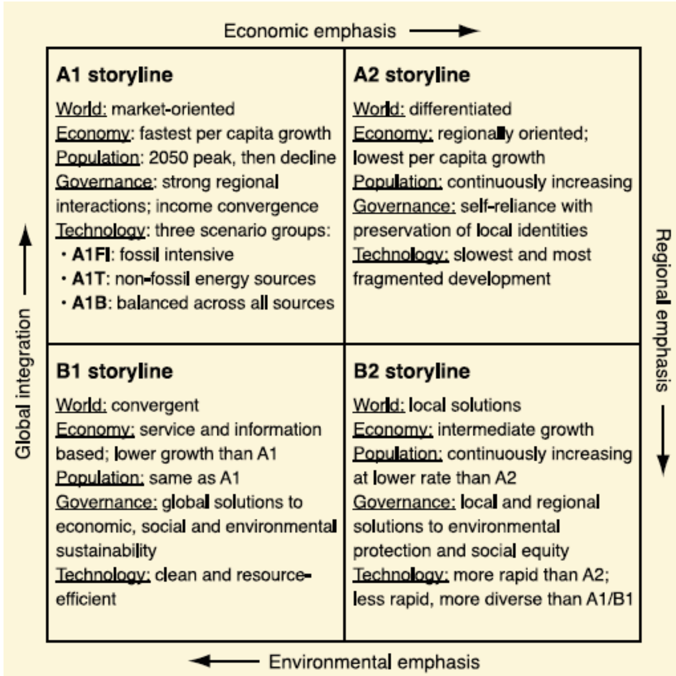
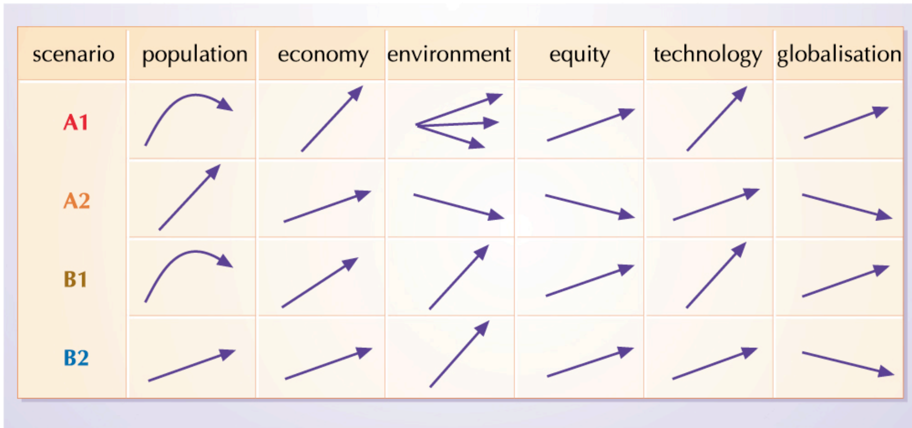
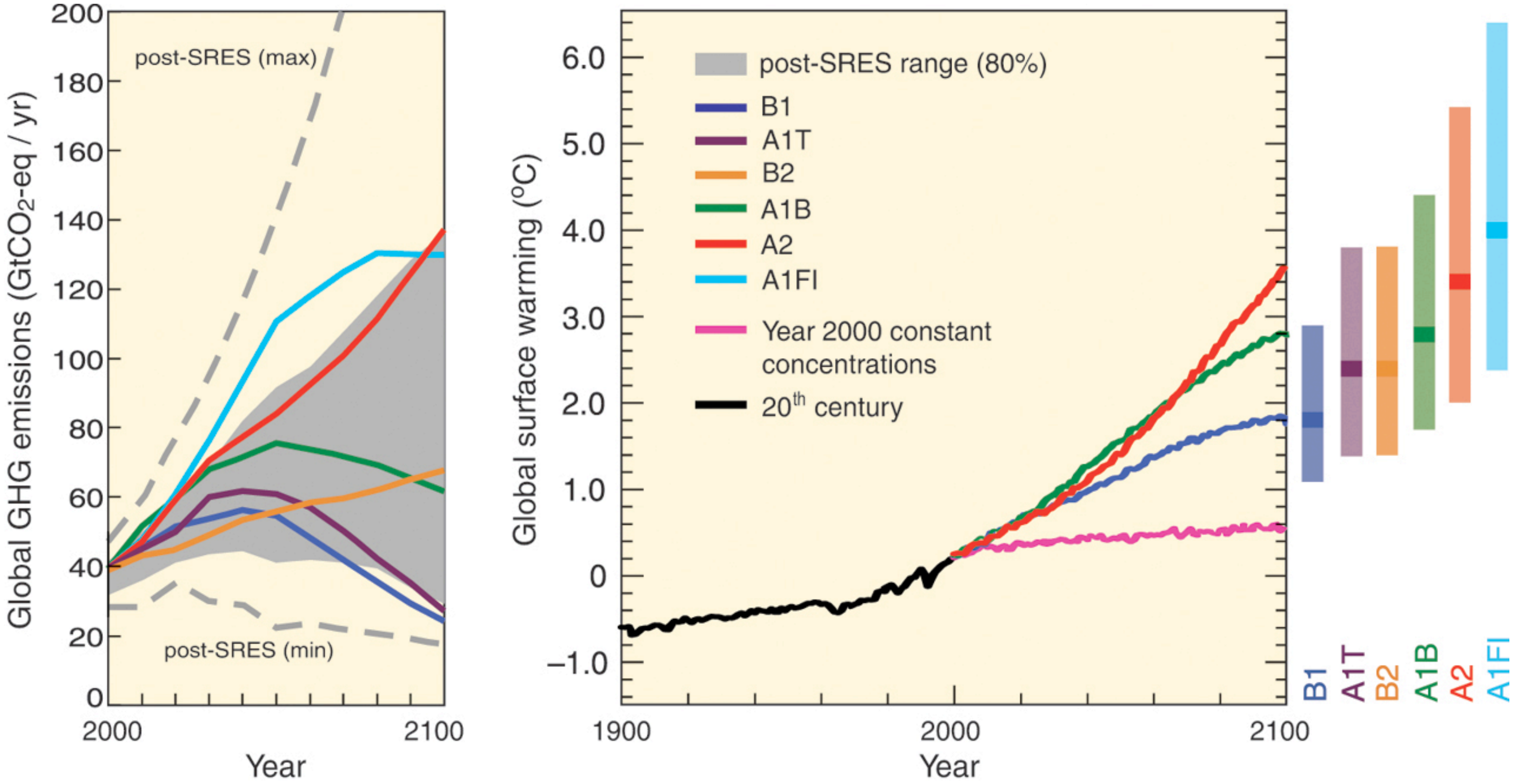
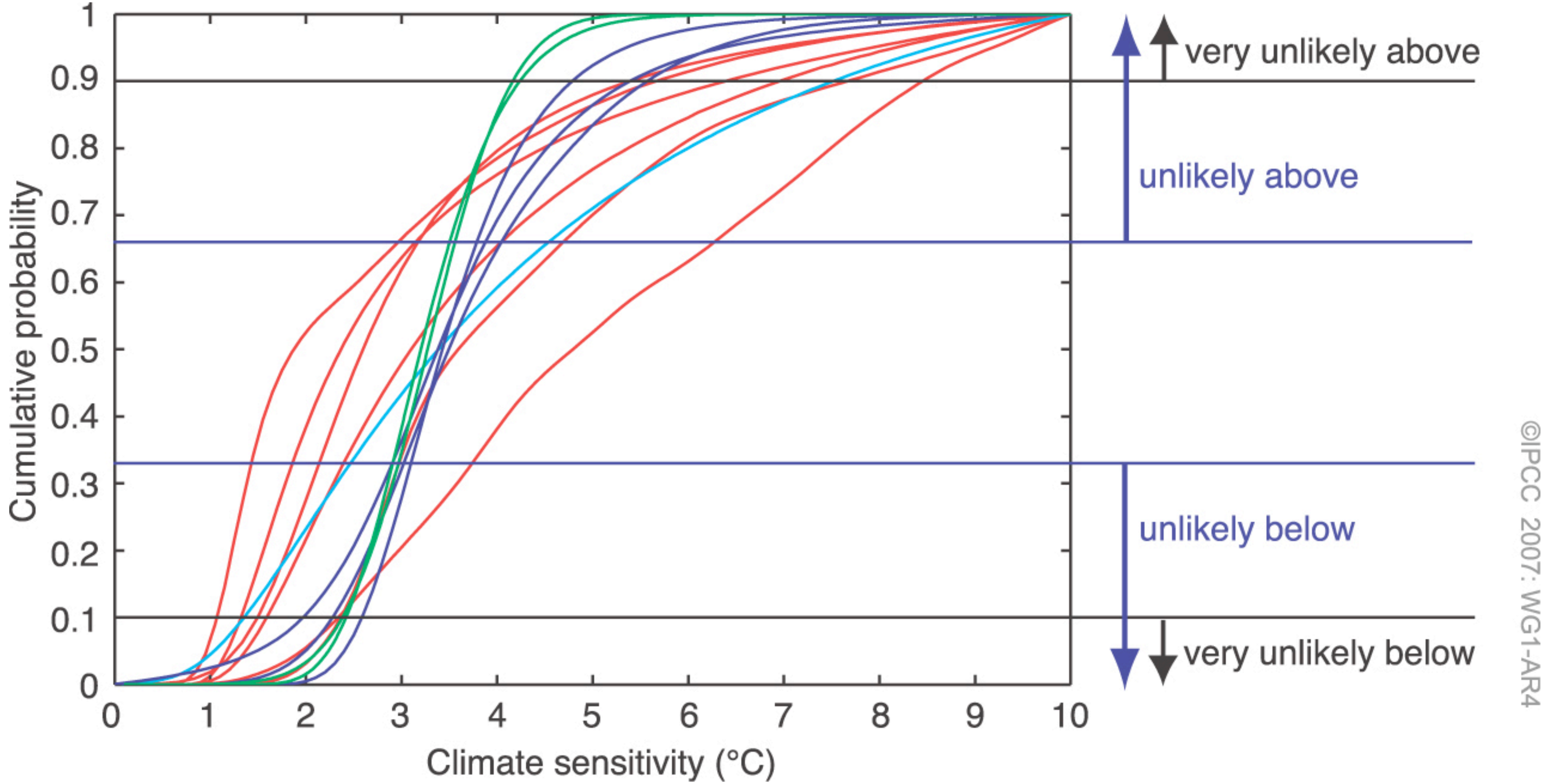


Figure 2.5. *Summary characteristics of the four SRES storylines (based on Nakićenović et al., 2000).*

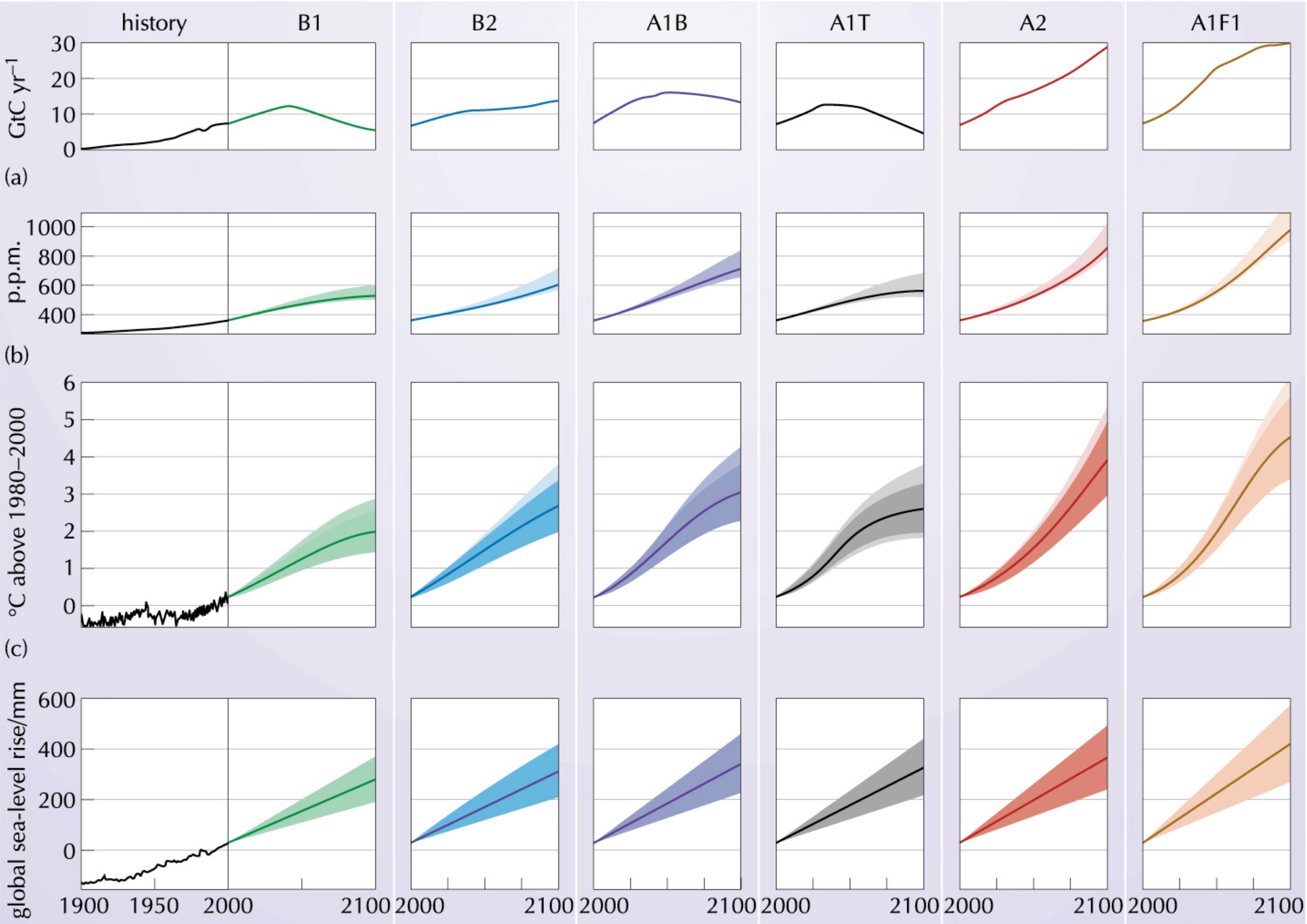




Source: IPCC, AR4 WG1 SPM

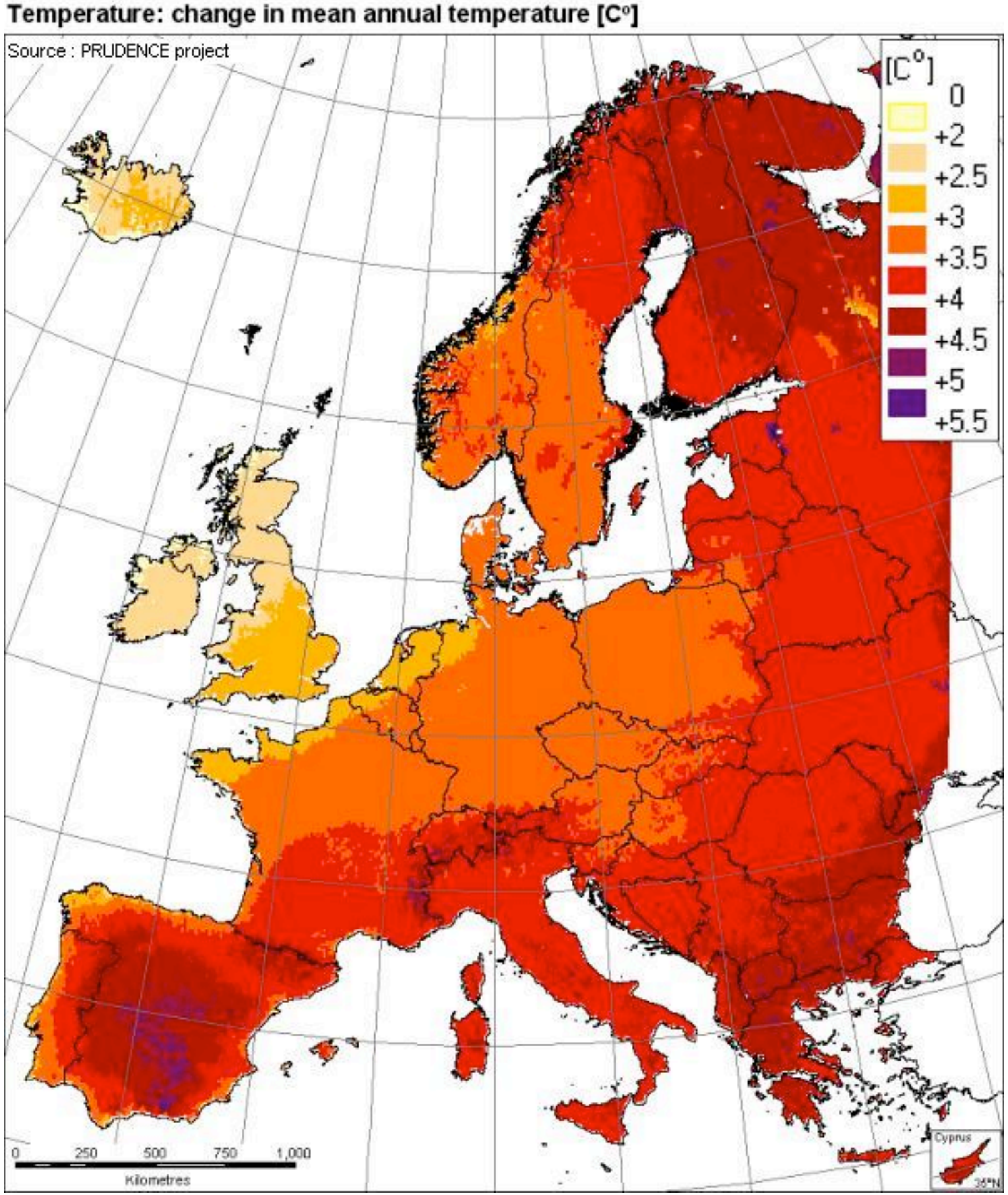


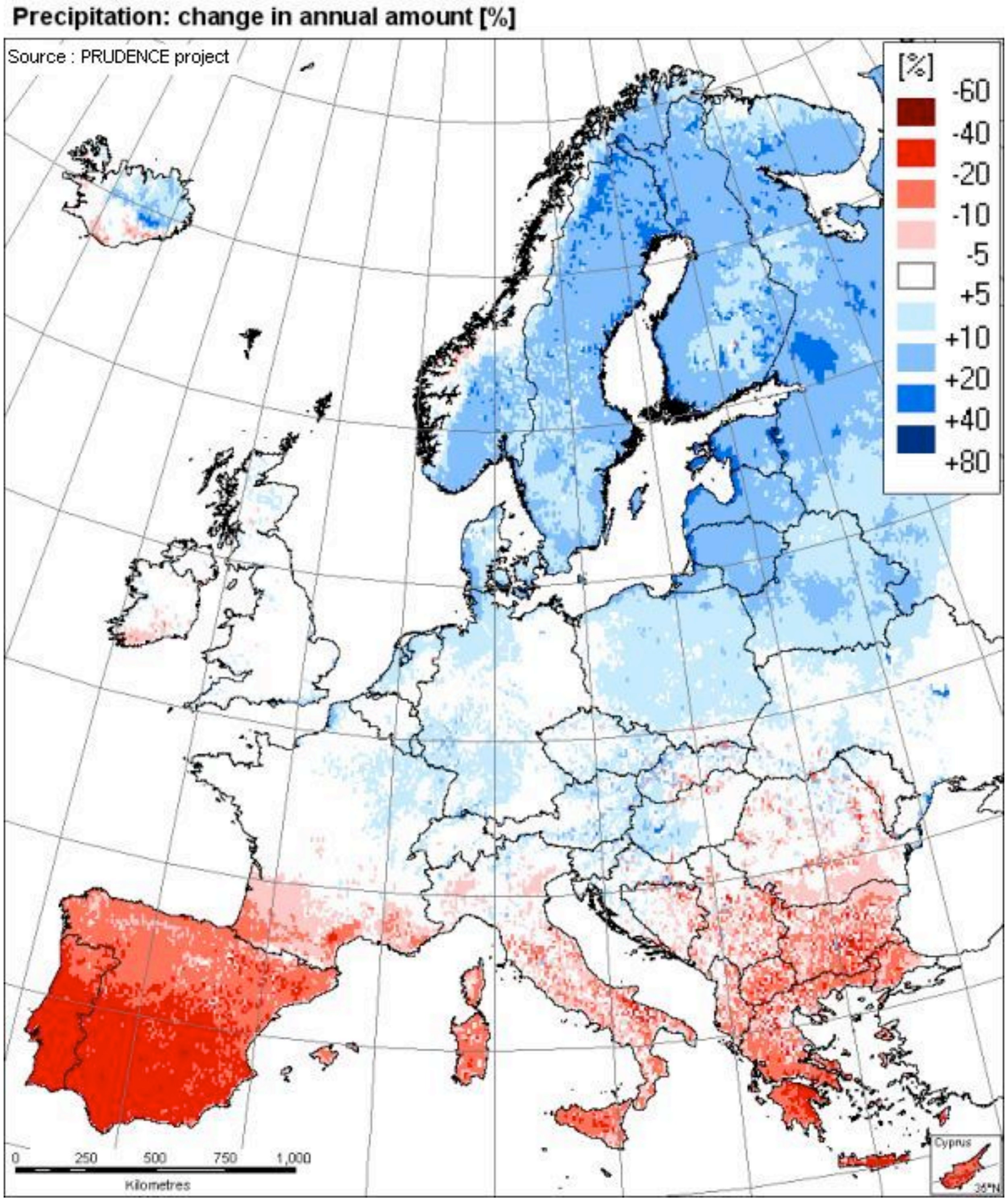
Cumulative probability
Climate sensitivity (°C)
very unlikely above
unlikely above
unlikely below
very unlikely below
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1
2
3
4
5
6
7
8
9
10
©IPCC 2007: WG1-AR4



Source: Peake and Smith , 2009

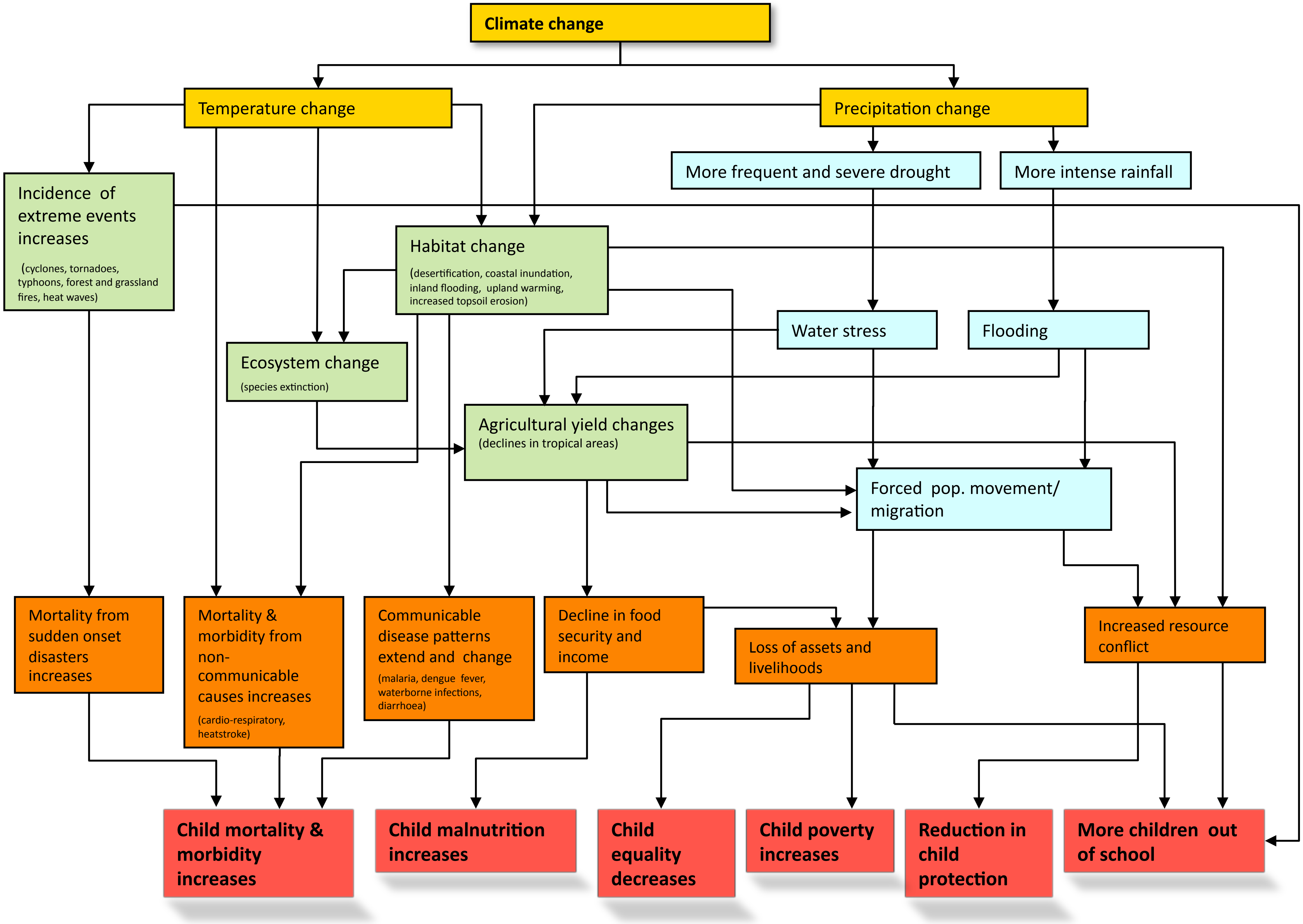
Absolute change in mean annual temperature between control period 1961-1990 and 2071-2100, under the IPCC SRES scenario A2. Data from EC-funded project Prudence (HadCM3 global circulation model, and HIRHAM regional climate model in 12km resolution), map elaboration by EC JRC/IES.



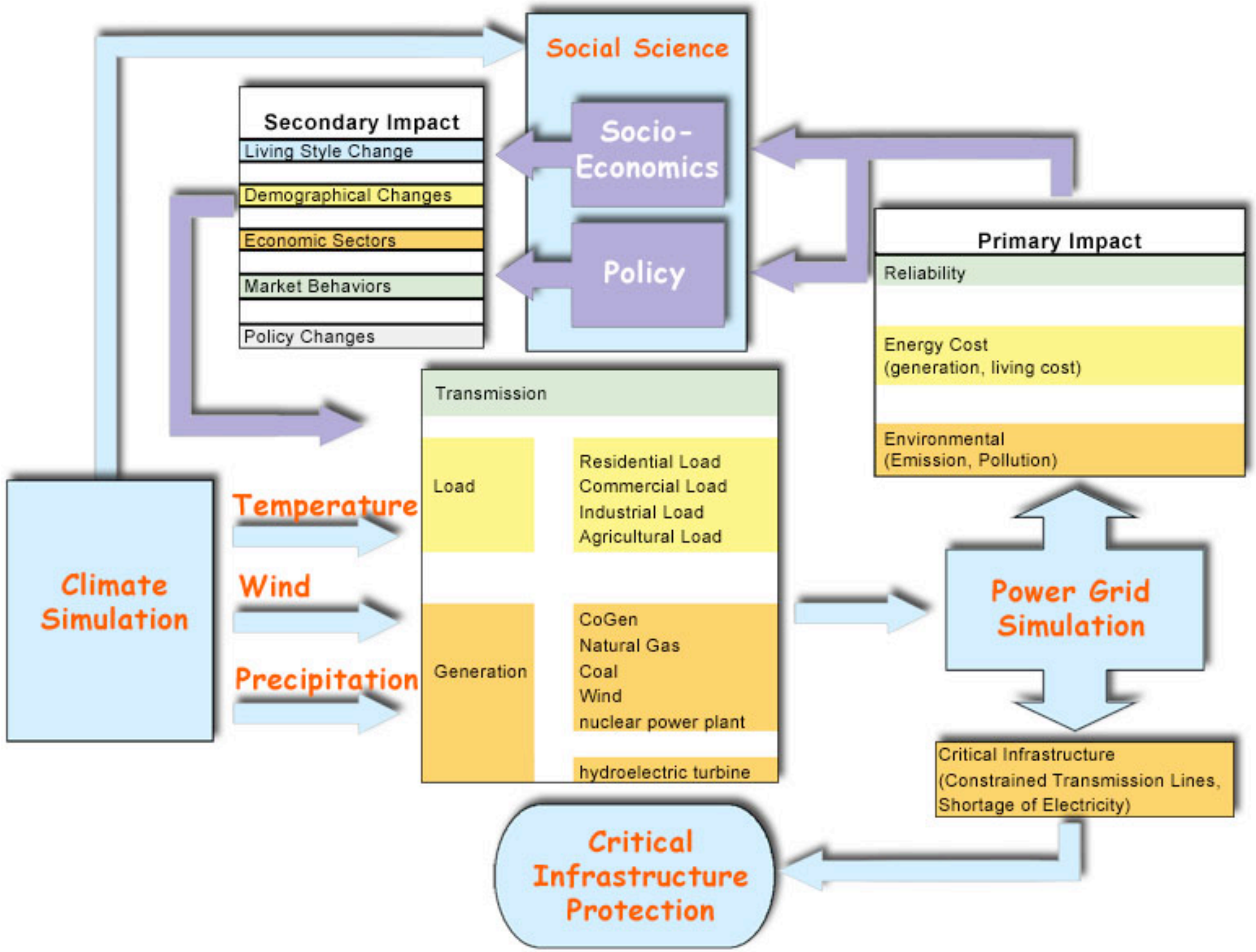


Relative change in mean annual precipitation between control period 1961-1990 and 2071-2100, under the IPCC SRES scenario A2. Data from EC-funded project Prudence (HadCM3 global circulation model, and HIRHAM regional climate model in 12km resolution), map elaboration by EC JRC/IES.

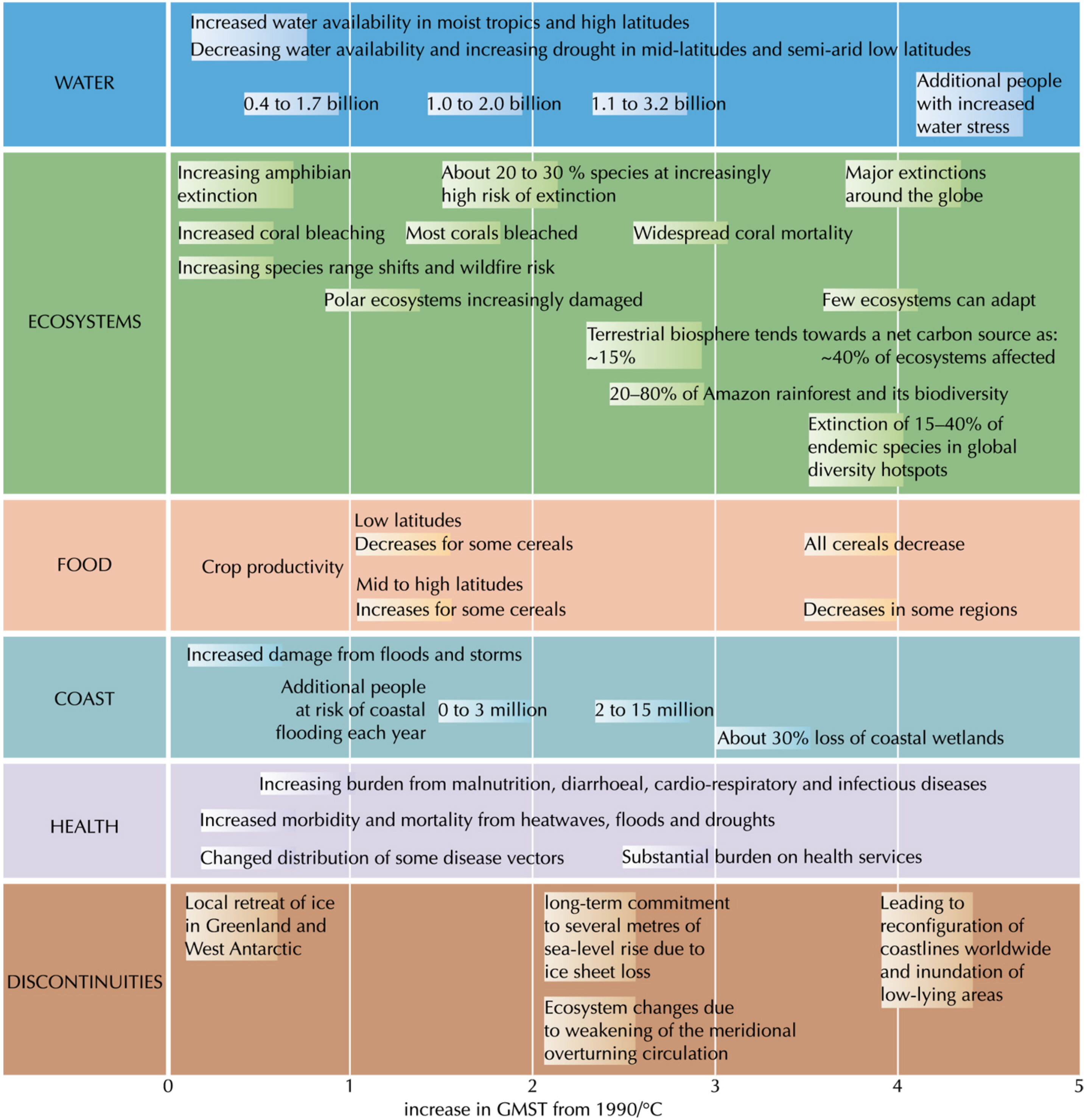
Source: Catherine Cameron, Agulhas



Predicting the Impact of Climate Change on U.S. Power Grids and Its Wider Implications on National Security



http://predictiveanalytics.pnl.gov/projects/impact_climate_change.stm



Source: Peake and Smith, 2009

WHAT IS POSSIBLE?

Balancing three costs

- Mitigation costs
- Adaptation costs
- Damage costs

(present values, sequential decision making)

- minimise MC(m) + AC(a) + D(m,a)

http://www.gefweb.org/Outreach/outreach-PUblications/Working_paper__16.pdf

Above is early paper from Fankhauser accessible to non-economists

Climate Response – easy as 1,2,3?

- 1. Allocate resources to climate problem versus other pressing global poverty, peace and security issues
- 2. Decide balance between Mitigation, Adaptation, Residual Damage
- 3. Decide a route to invest time, money effort
  - Legal (e.g. UNFCCC/KP)
  - Markets (Trading, Tax, Mechanisms)
  - Technologies
  - Behaviour/Norms

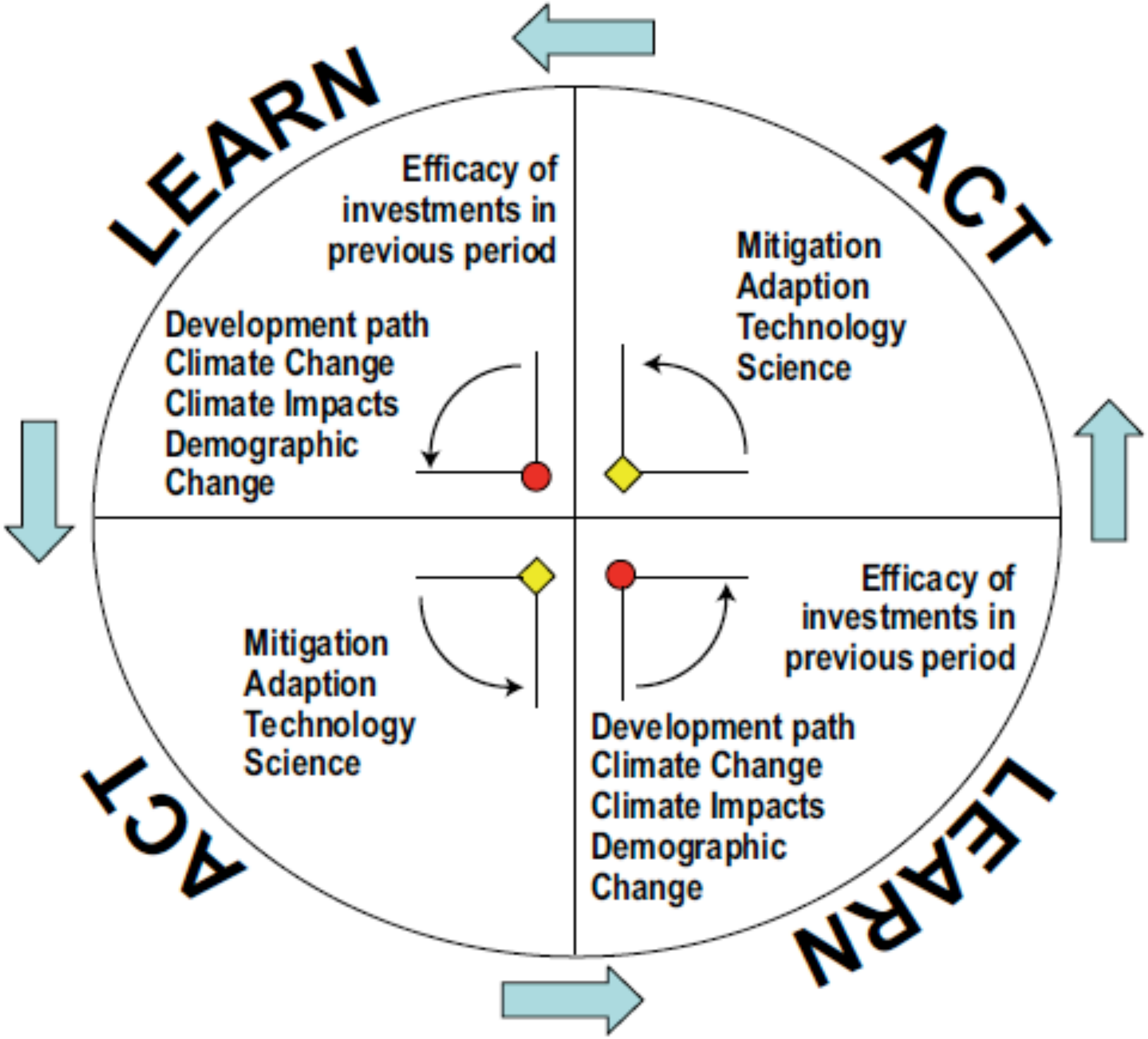


Figure 3.37: *The Iterative Nature of the Climate Policy Process.*

$100/tCO2 buys a lot of sectoral change

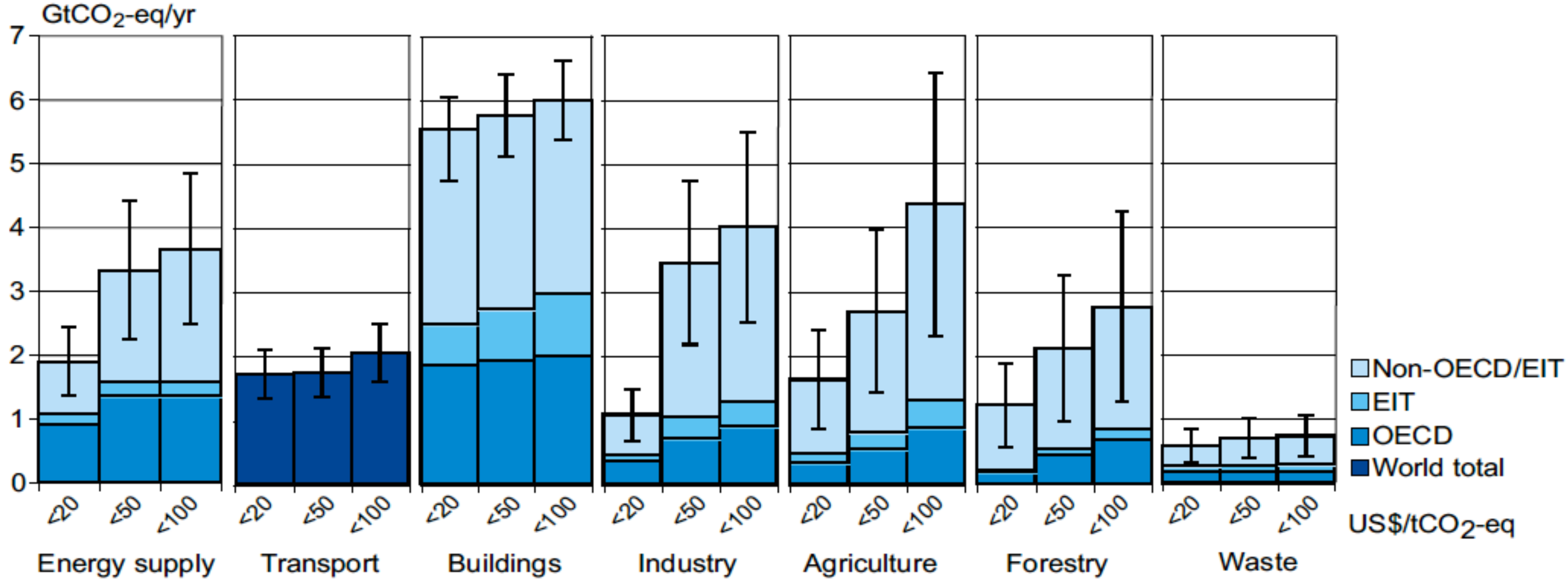
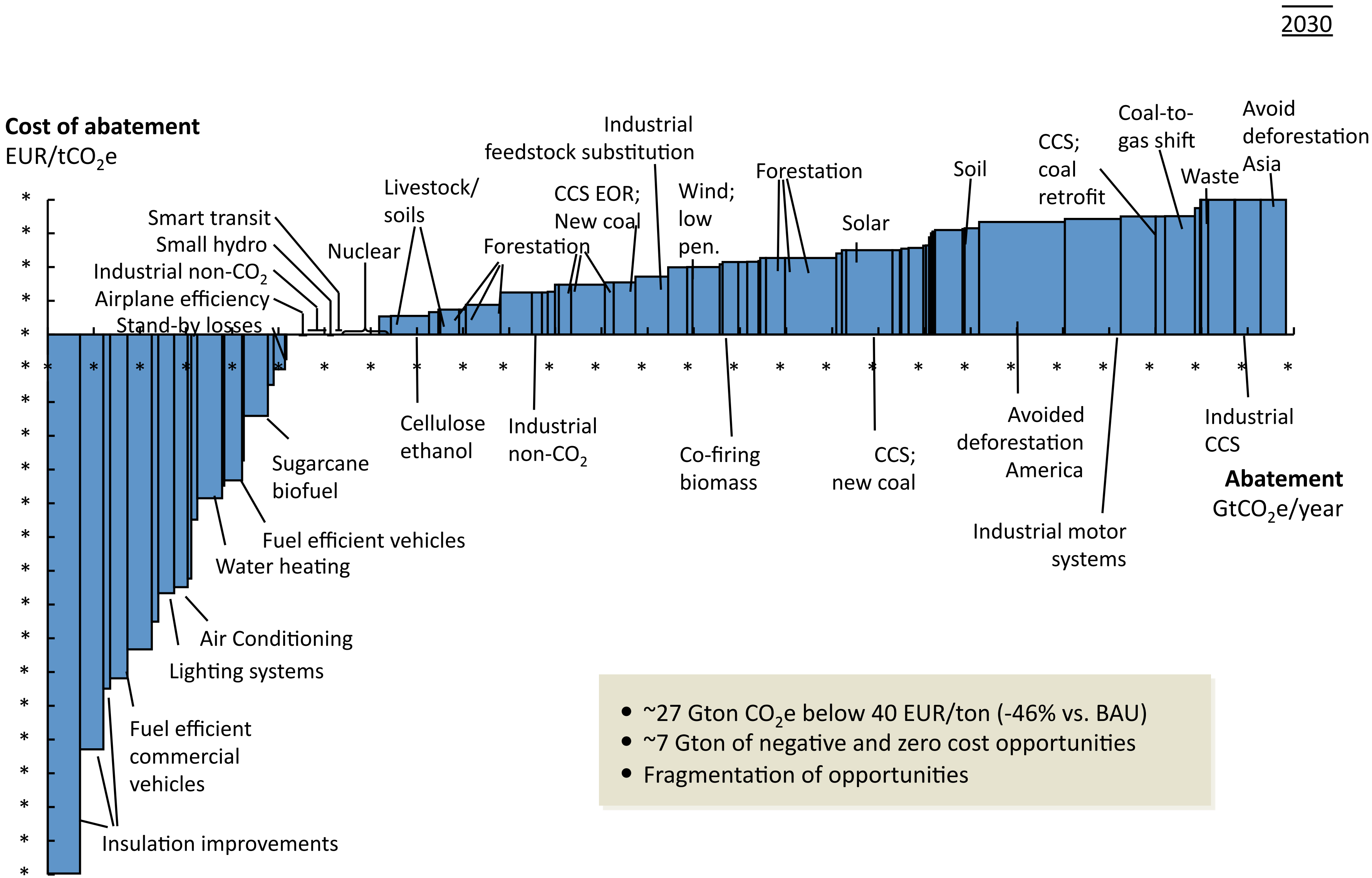


Figure TS.27: *Estimated sectoral economic potential for global mitigation for different regions as a function of carbon price in 2030 from bottom-up studies, compared to the respective baselines assumed in the sector assessments. A full explanation of the derivation of this figure is found in Section 11.3.*

McKinsey bottom-up approach



- ~27 Gton CO_2e below 40 EUR/ton (-46% vs. BAU)
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

Source: Catherine Cameron, Agulhas

Table SPM.3: *Key mitigation technologies and practices by sector. Sectors and technologies are listed in no particular order. Non-technological practices, such as lifestyle changes, which are cross-cutting, are not included in this table (but are addressed in paragraph 7 in this SPM).*

Sector	Key mitigation technologies and practices currently commercially available	Key mitigation technologies and practices projected to be commercialized before 2030
Energy supply [4.3, 4.4]	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of Carbon Capture and Storage (CCS, e.g. storage of removed CO_2 from natural gas).	CCS for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and waves energy, concentrating solar, and solar PV.
Transport [5.4]	More fuel efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning.	Second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries.
Buildings [6.5]	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation ; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycle of fluorinated gases.	Integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar PV integrated in buildings.
Industry [7.5]	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO_2 gas emissions; and a wide array of process-specific technologies.	Advanced energy efficiency; CCS for cement, ammonia, and iron manufacture; inert electrodes for aluminium manufacture.
Agriculture [8.4]	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency.	Improvements of crops yields.
Forestry/forests [9.4]	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use.	Tree species improvement to increase biomass productivity and carbon sequestration. Improved remote sensing technologies for analysis of vegetation/ soil carbon sequestration potential and mapping land use change.
Waste management [10.4]	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimization.	Biocovers and biofilters to optimize CH_4 oxidation.

Climate modelling compounds

- Science models
- Population models
- Emissions models
- Impact models
- Economic models
- Integrated Assessment models
- Policy models
- Political models
- Business models
- Social models

Uncertainties and scenario analysis

- Three types of uncertainty: uncertainty in quantities, uncertainty about model structure and uncertainties that arise from disagreements among experts about the value of quantities or the functional form of the model (Morgan and Henrion, 1990)
- Sources of uncertainty could be statistical variation, subjective judgment (systematic error), imperfect definition (linguistic imprecision), natural variability, disagreement among experts and approximation (Morgan and Henrion, 1990). Others (Funtowicz and Ravetz, 1990) distinguish three main sources of uncertainty: "data uncertainties,""modeling uncertainties" and "completeness uncertainties."
- Data uncertainties arise from the quality or appropriateness of the data used as inputs to models. Modeling uncertainties arise from an incomplete understanding of the modeled phenomena, or from approximations that are used in formal representation of the processes. Completeness uncertainties refer to all omissions due to lack of knowledge. They are, in principle, non-quantifiable and irreducible.

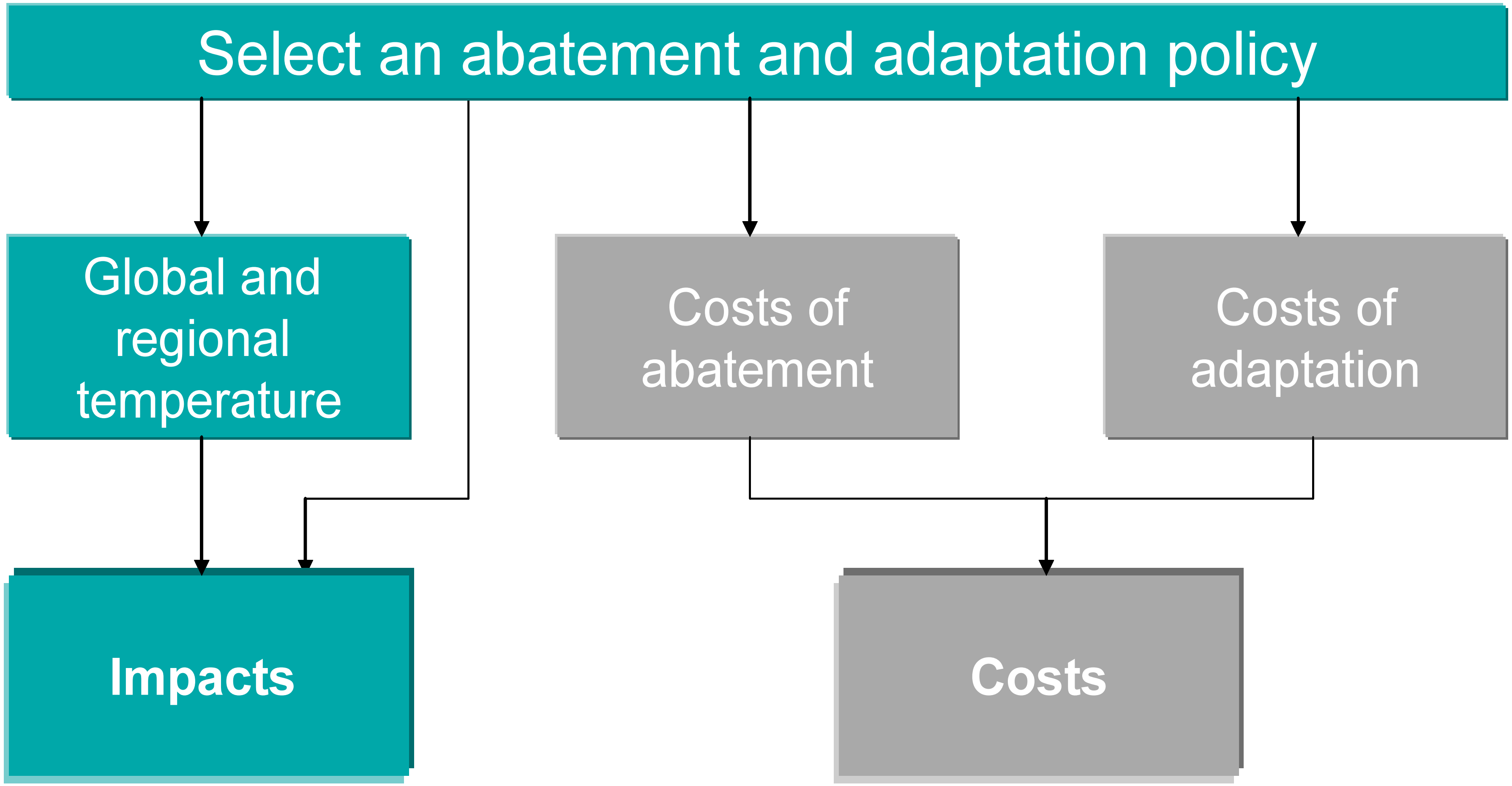
http://www.grida.no/Climate/ipcc/emission/025.htm

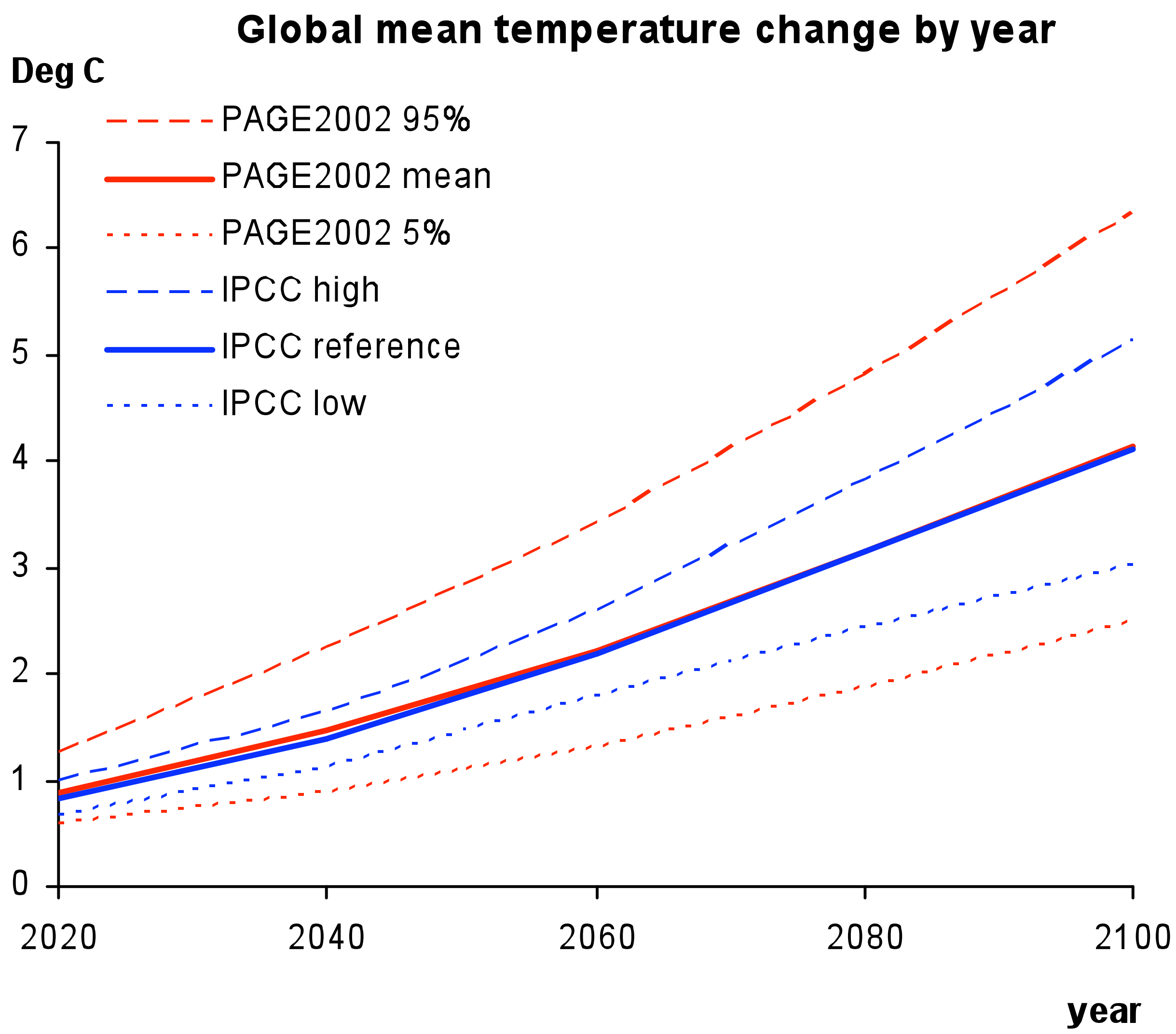
All these are modelling outputs

- Climate sensitivity (e.g. “what is delta T for 1.5x CO2?”)
- Emissions scenarios (e.g. “what will emissions be in 2080?”)
- Marginal abatement costs (e.g. “What is cost of reducing emissions in 2030 by 20GtC?”)

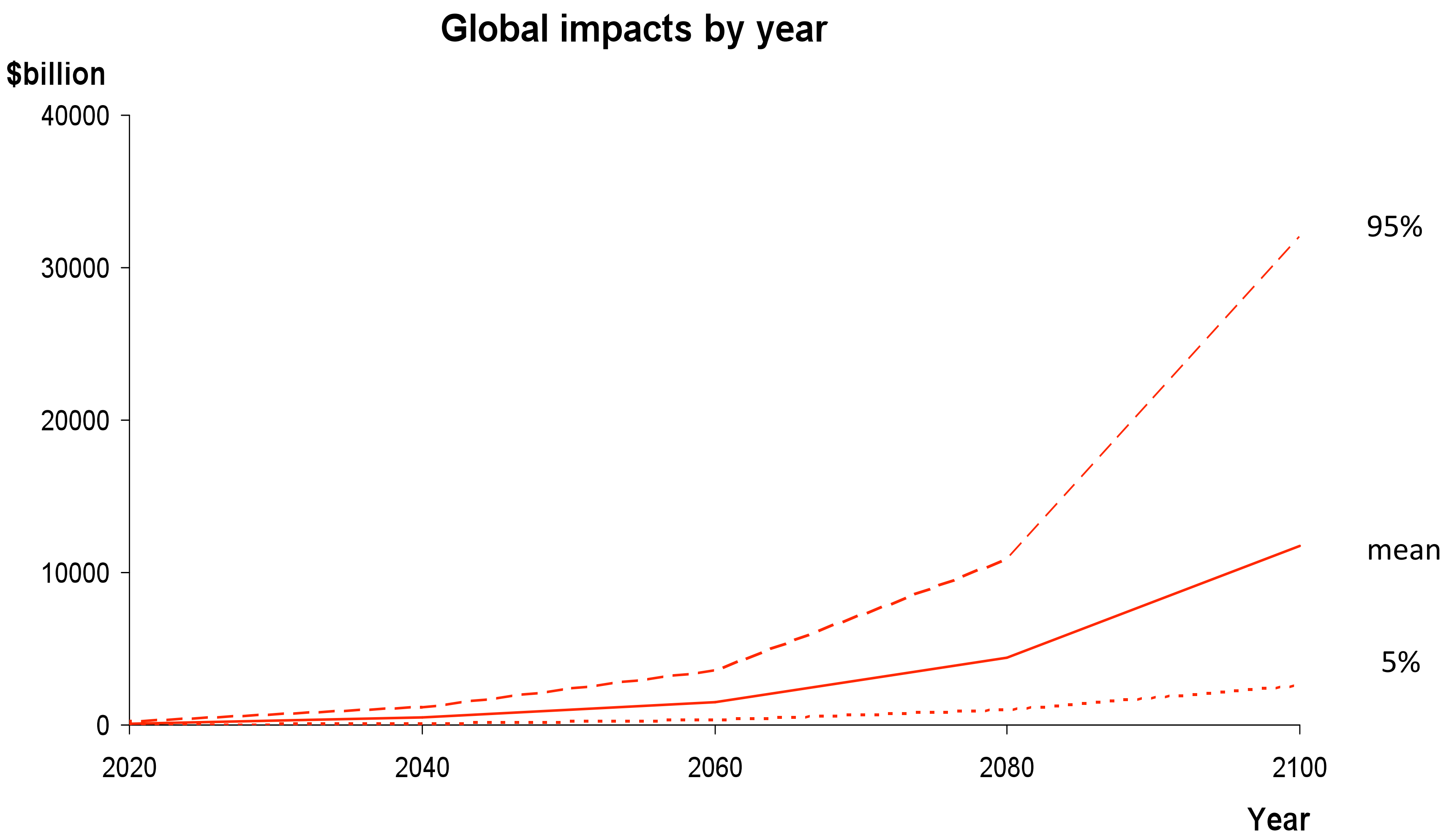
….use same conceptual apparatus for all of the above – ie subjective probabilities
and this can be then informed by experts/data/etc (baysian subjective prob distributions)

Chris Hope, University of Cambridge
Structure of the PAGE2002 model





IPCC Scenario A2



5% mean 95%

Total global impacts 10 70 200 $ trillion

IPCC Scenario A2

WHAT IS FAIR?

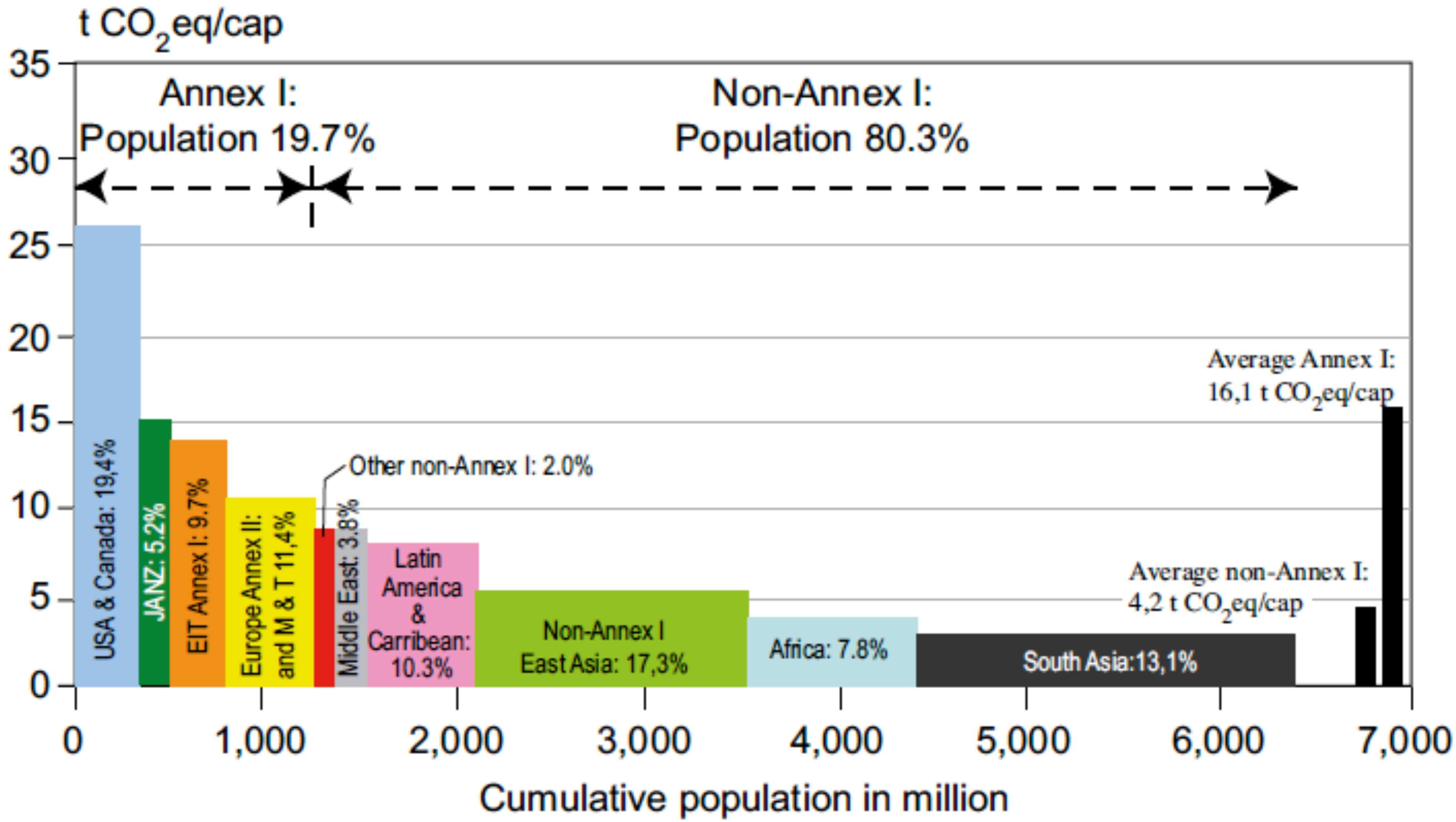


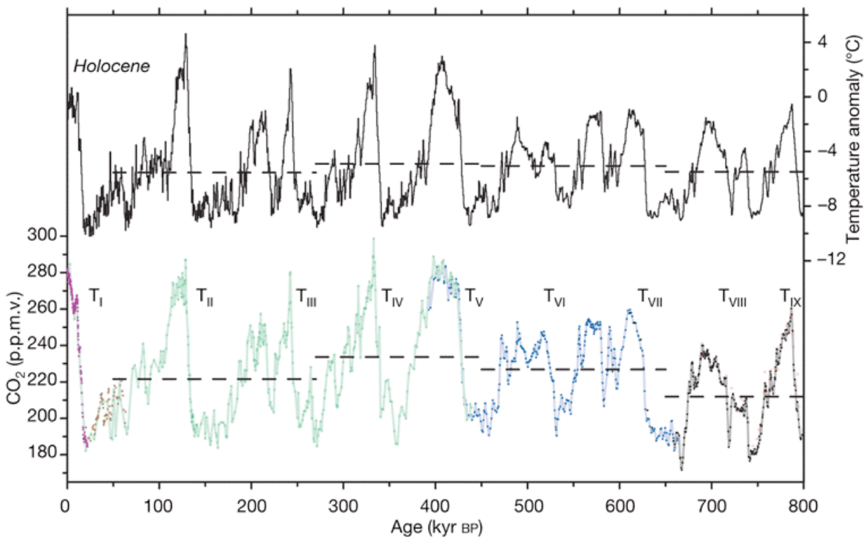
Figure TS.4a: *Distribution of regional per capita GHG emissions (all Kyoto gases including those from land-use) over the population of different country groupings in 2004. The percentages in the bars indicate a region's share in global GHG emissions [Figure 1.4a].*

Key equity principles underpinning negotiations

- Egalitarian: each human being has an equal right to use the atmosphere; this translates into schemes based on per capita entitlement.
- Sovereignty and acquired rights: all countries have a right to use the atmosphere and current emissions constitute a 'status quo right'; this translates into schemes based on grandfathering entitlements.
- Responsibility / polluter pays: the greater the contribution to the problem, the greater the share in the mitigation / economic burden.
- Capability: the greater the capacity to act or ability to pay, the greater the share in the mitigation / economic burden.

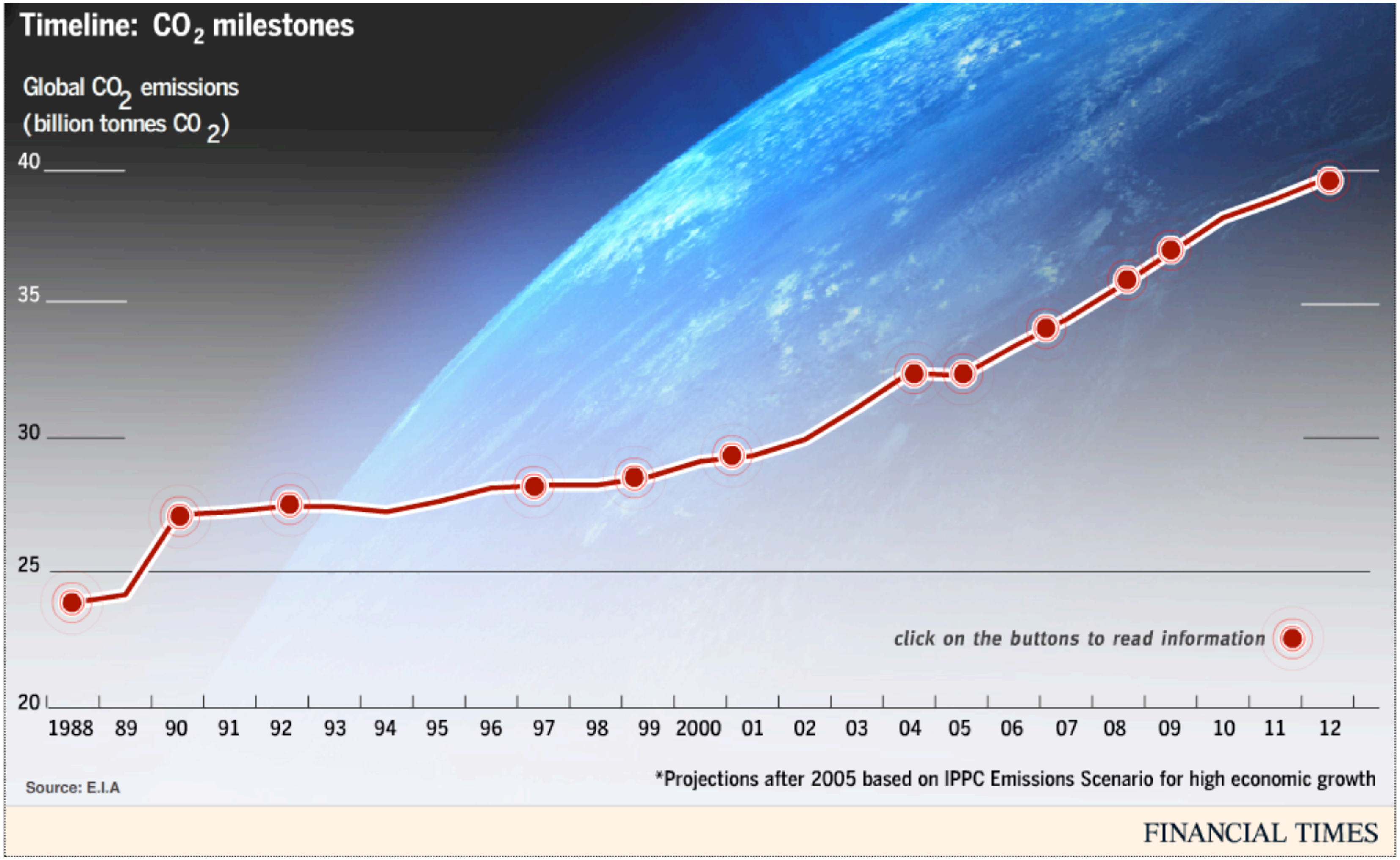
WHAT IS ACHIEVABLE?

we are moving slowly – weighed down by the challenges of international law based on sound science…



…both science and law are highly inertial, and are being joined by
“involuntary” (autonomous, national and regional)
approaches ahead of post Kyoto

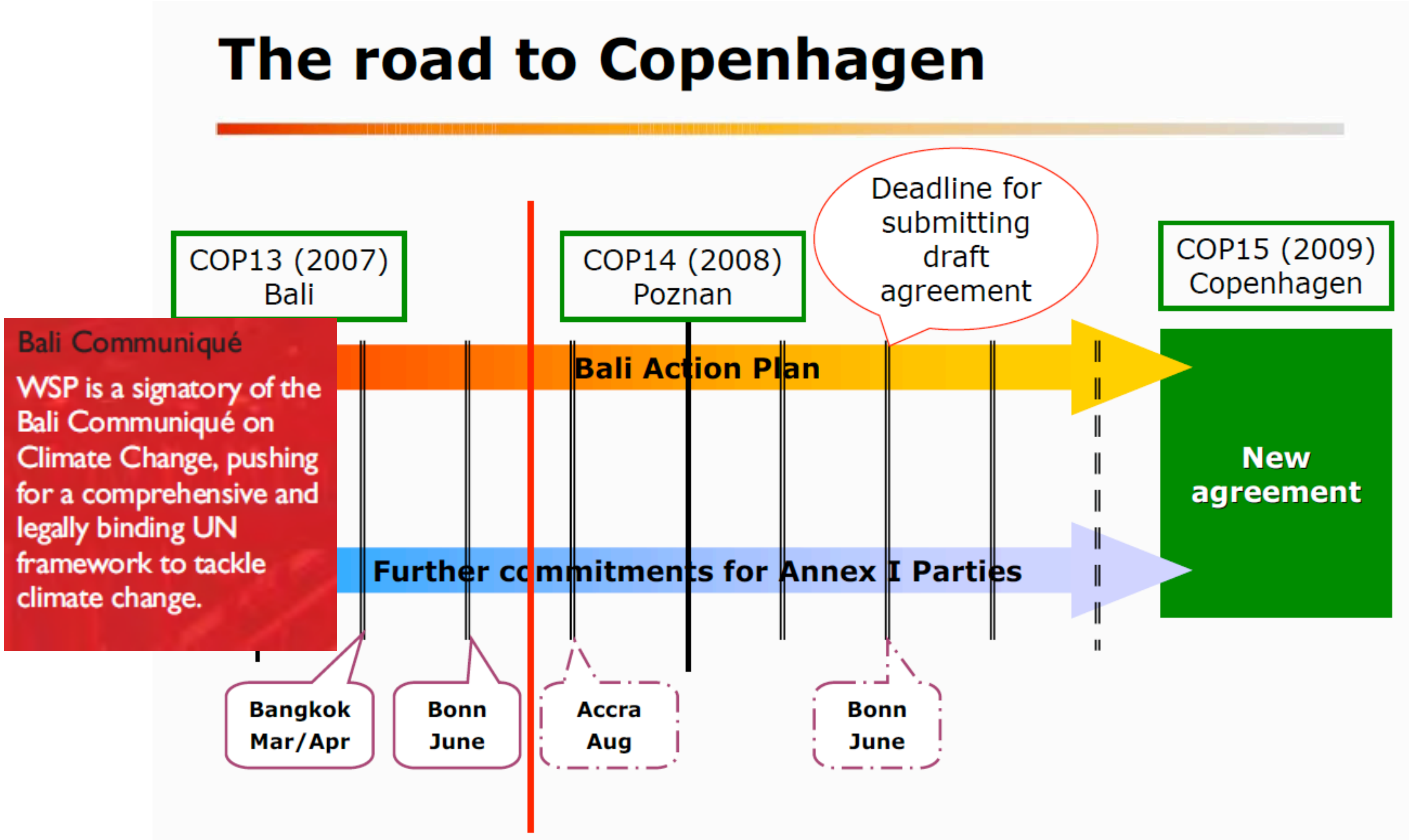
2012 end of Kyoto 1
first commitment period



20 years is a short time in the climate system

- Some business is quarter to quarter (some is the order of decades – electricity/gas – analysis over 20 years)
- Strategy is 1-2 years
- Climate policy has been order of decades
- Human lifespan is 70 years
- Climate change is century-scale

The Copenhagen Crescendo



Source: UNFCCC

2009 Copenhagen Deal

- Radical emission reductions by industrialised countries (25-40% over 1990 levels by 2020)
- Meaningful engagement developing countries:
  - measurable, reportable verifiable action (no binding commitments)
  - REDD pilot phase
  - measurable, reportable and verifiable financial support and technology transfer for developing countries:
  - to help green their economic growth
  - to help developing countries adapt

Source: UNFCCC

- UNFCCC
  - Adaptation
  - Technology Transfer
  - REDD
- Kyoto 2
  - QUELROS
  - Flexibility Mechanisms
  - Compliance

Some complex ethical dynamics behind the negotiations

What if we fail to reach int agreement?

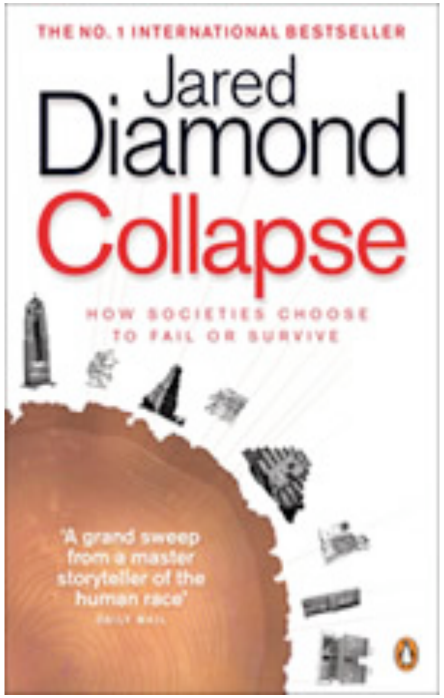
- Adaptation will happen autonomously
- Mitigation in AI continues
- E8 major emitters get together
- Worst effects become more severe
- Positive significant carbon prices for the rest of the next century under regional schemes – whatever happens
- Low carbon, sustainable design is required (even more so!)

Climate Intervention
Medicine or Political Milkshake?

Task is to change perception from this…

…to this

Collapse and environmental change



Ancient societies that collapsed because of environmental (and other) reasons:

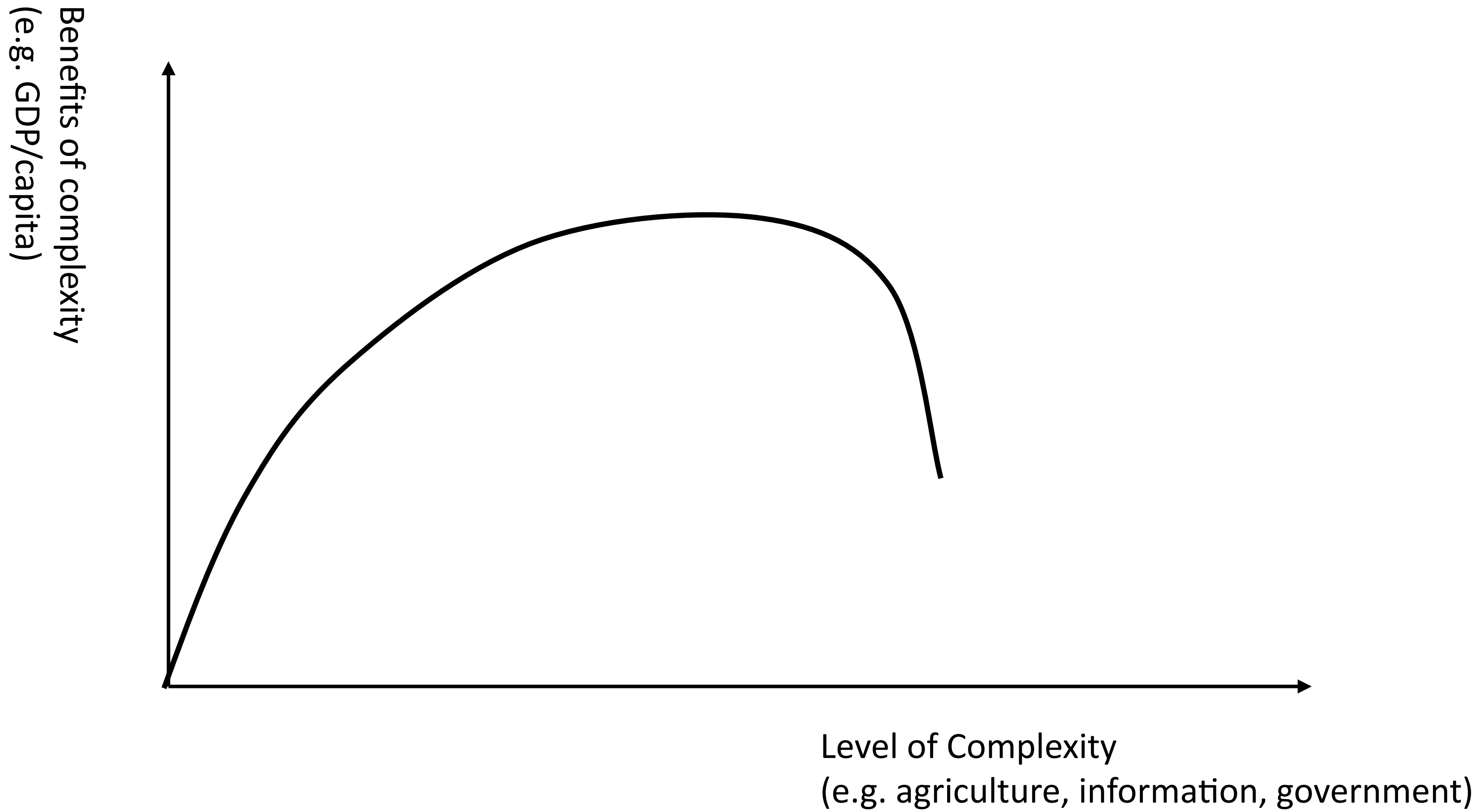
- Classic Mayan
- Easter Islanders,
- Greenland Norse

Twelve time bombs with fuses of less than 50 years

- **Destruction of natural resources**
  - Habitats
  - Wild food sources
  - Biological diversity
  - Soil
- **Ceilings on resource use**
  - Energy
  - Water
  - Photosynthesis
- **Harmful things we generate or move around**
  - Toxic chemicals
  - Alien species
  - Atmospheric gases
- **Human population**
  - Increases in population
  - Impact per person

Source: J Diamond, 2005, Collapse, Penguin books, Chapter 16

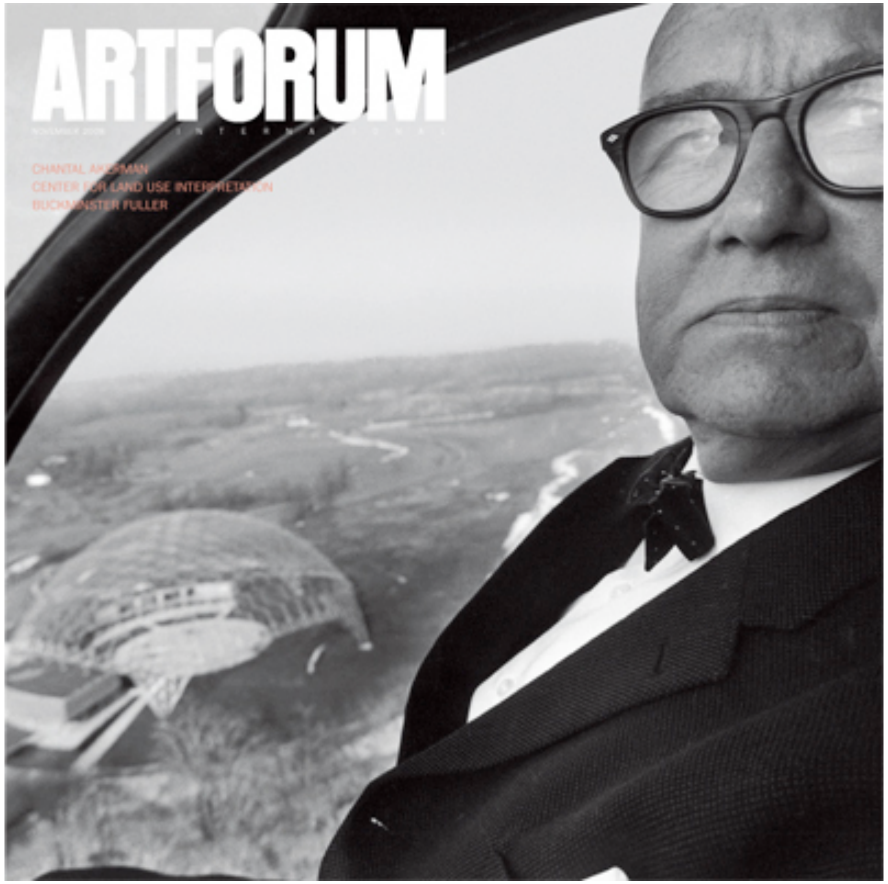
Collapse and the declining productivity of complexity



Source: Tainter (1988)

1960s – “Design Science Decade”

- radical technologist Buckminster Fuller called for a “design science revolution” based on science, technology, and rationalism to overcome the human and environmental problems that he believed could not be solved by politics and economics.



Decisions and chances

- Decision node – something we have control over
- Chance node – something we have no control over
- So stabilisation level for business becomes a chance node. But for government, large business it is not a chance node, it can be a decision node….
- Problem comes when we conflate actions and chance nodes ….

Designing for the environment – 4 strategies

- Green design – materials, energy or toxic emissions
- Eco-design – life cycle design from 'cradle to grave'
- Sustainable design – environmental, social & economic factors
- Sustainable innovation – systems level, radical design

Prof Robin Roy, Open University

Design brief is climate (carbon + adaptation) + sustainable development synergies

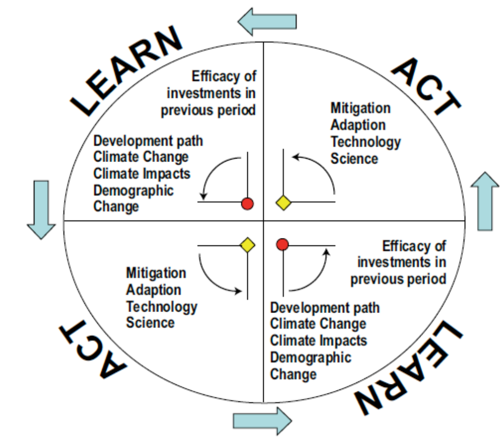
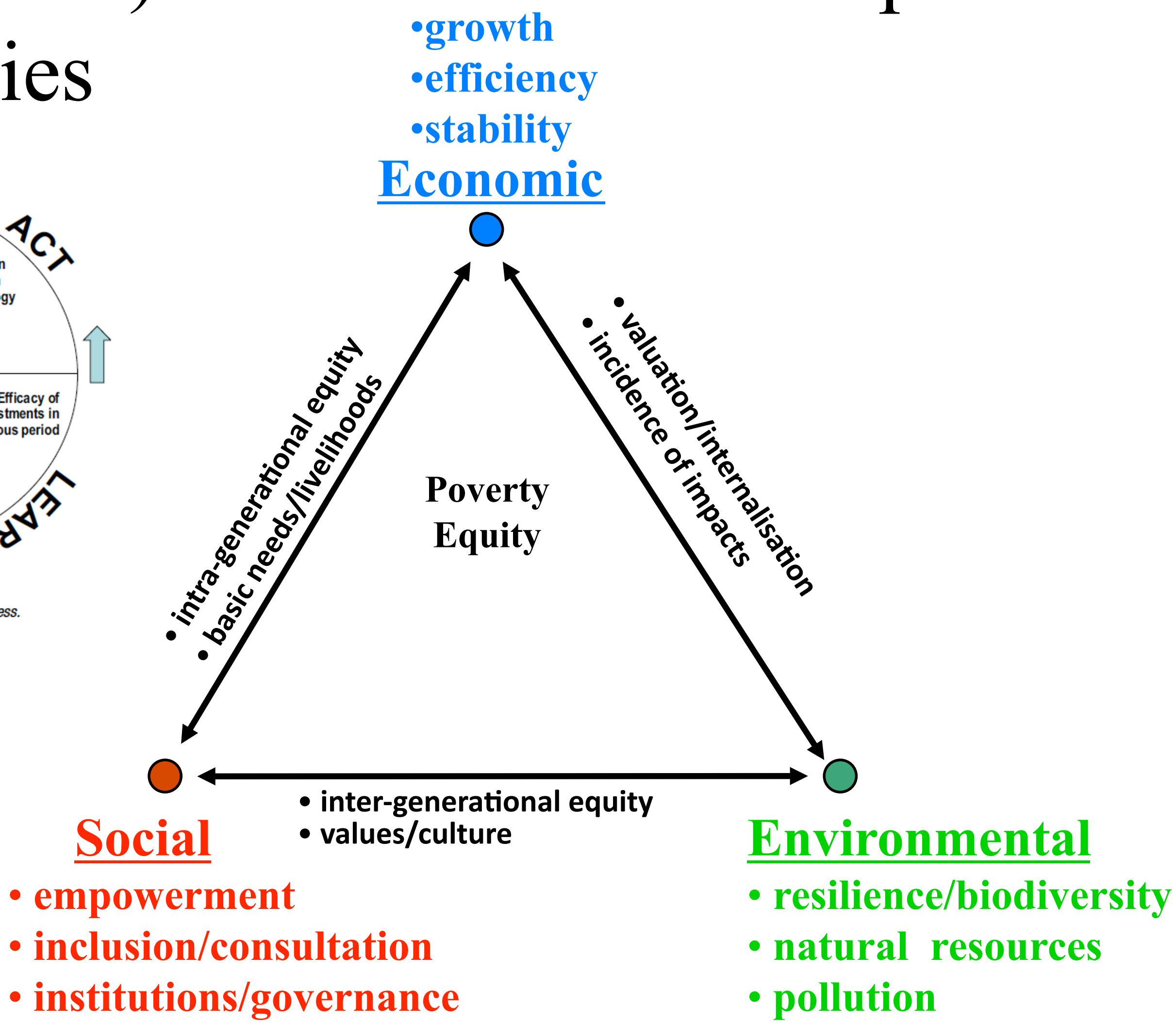


Figure 3.37: *The Iterative Nature of the Climate Policy Process.*



Source: M Munasinghe, 1992, Environmental Economics and Sustainable Development, Rio Earth Summit, World Bank, Washington DC.