AVOIDING DANGEROUS CLIMATE CHANGE:
OVERVIEW OF IMPACTS

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Outline

• **What** key impacts (key vulnerabilities, ‘thresholds’)?
  – what scale (global, regional, local)
  – what sector / system (food, ecosystems, SD…. other)

• **When** do these occur (timing of exceedance), under different projected future climate changes?

• **How** can these exceedances be delayed or avoided?
  – by reducing rate of climate change
  – by raising the thresholds (i.e. increasing resilience, adaptation)
1. **What Key Impacts?**

   • How to identify / measure them
Three approaches to classifying dangerous impacts of climate change

1. **Integrated assessment models**: spatially explicit models of impacts often linked to energy/emissions models and scenarios; run in forward or reverse mode (e.g. IMAGE, ICLIPS, RICE)
Aggregate global damage estimates

- Driven by outcomes in the agriculture sector
- Non-market impacts, extreme events and non-linear, abrupt change either not represented or based on gross, admittedly erroneous assumptions
- Use different assumptions (i.e. aggregation, baselines, valuation)
- Lack of transparency
- Incomplete and inconsistent coverage of sectors and treatment of uncertainty

Smith et al. 2001; from: Mendelsohn and Schlesinger, 1997; Nordhaus and Boyer, 2000; Tol, 2002b
Three approaches to classifying dangerous impacts of climate change

1. Integrated assessment models: spatially explicit models of impacts often linked to energy/emissions models and scenarios; run in forward or reverse mode (e.g. IMAGE, ICLIPS, RICE)

2. Mixed modelling approach: spatially explicit impact models for different sectors/indicators run in parallel globally or regionally for consistent scenarios, including adaptive capacity (e.g. Millions at Risk, ATeam)
Global Additional Millions at Risk in the 2080s
(Global Env. Change, 2001 from UK DEFRA ‘fast track’ project)

Legend
- Blue: Risk of water shortage
- Green: Risk of malaria
- Red: Risk of hunger
- Purple: Risk of coastal flooding

Hadley Centre models; simple best estimate future pop and econ
### Three approaches to classifying dangerous impacts of climate change at **regional** scale

1. **Integrated assessment models**: spatially explicit models of impacts often linked to energy/emissions models and scenarios; run in forward or reverse mode (e.g. IMAGE, ICLIPS, RICE)

2. **Mixed modelling approach**: spatially explicit impact models for different sectors/indicators run in parallel globally or regionally for consistent scenarios, including adaptive capacity (e.g. Fast Track; ATEAM)

3. **Multiple source, expert assessment approach**: mainly regional and local in focus; multiple scenarios and assumptions; adaptation and mitigation treated at regional scale (WBGU/Hare; IPCC AR4?)
Relationship between global mean temperature change and estimated impacts on coastal wetlands

Australia, Kakadu region: Loss of, or serious damage to, Kakadu World Heritage listed wetlands (3.0°C to 1.7°C range of 1.2°C to 3.1°C) (6)

Bangladesh, Sundarbans: Progressive loss of mangrove forest and wetlands, including habitat of Bengal tiger (75% loss at 2.5°C) (6)

European wetlands: Mediterranean coast (31-100% loss for 2.4-4.4°C warming in 2080s) (7)

European wetlands: Baltic coast (84-98% for 2.6-4.4°C warming in 2080s) (6)

European wetlands: Atlantic coast (0 to 17% loss for 2.6-4.4°C warming in 2060s) (5)

USA: Delaware - Loss of 21% ca. 2.5-3.5°C warming - 100-year floods occurring 3-4 times more frequently (4)

USA: Loss of important foraging, migratory and wintering bird habitat at four sites (25-70% loss for ca. 2.6°C warming) (3)

USA: Southern New England - Extensive loss of wetlands if sea level rise greater than 6 mm/yr (2)

Global assessment: Low - Progressive coastal wetland loss with increasing warming (5.7% for ca. 3.4°C warming) (1b)

Global assessment: High - Progressive coastal wetland loss with increasing warming (22.2% for ca. 3.4°C warming) (1a)

Source: Hare (2003)
What does the global impacts literature tell us?

- Relationships vary across sector
- No global studies in some areas: recreation and tourism; transport; building; insurance; human amenity

Indicative shapes of damage curves:

- Parabolic
- Increasing adverse
- Unknown

Source: based on Hitz and Smith 2004
• Further complexity is added by effects of different possible future development pathways, which affects a) vulnerability, and b) adaptive capacity. i.e. RISK DEPENDS ON RESILIENCE

example:

<table>
<thead>
<tr>
<th></th>
<th>A2 in 2050s</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pop</td>
<td>11.3 billion</td>
<td>9.3 billion</td>
</tr>
<tr>
<td>GDP</td>
<td>82 tr $</td>
<td>110 tr $</td>
</tr>
<tr>
<td>Energy</td>
<td>970 GJ/yr</td>
<td>870 GJ/yr</td>
</tr>
<tr>
<td>Carbon</td>
<td>16 GtC/yr</td>
<td>11 GtC/yr</td>
</tr>
</tbody>
</table>
Additional People at Risk of Hunger under the SRES A2 and B2 Scenarios,
(Parry, et al in Global Environmental Change, April 2004)

Therefore risk depends on resilience
2. **When** might these key impacts / key vulnerabilities / ‘thresholds’ be exceeded?
Key impacts on wheat yields for different regions

N. India
S. Europe
W. England

Deg C

% Yield

0.5
1.0

Local food production?
Regional food security?
Global food security?
Some Climate Impacts Are Already Critical at Local/Regional Levels

*Glacier retreat and glacial lake expansion in Nepal:* increased risk of GLOFs with impacts on infrastructure and livelihoods; altered water and energy outlook

Photo source: Department of Hydrology, Nepal

OECD 2003; Development and Climate Change in Nepal: Focus on Water Resources and Hydropower
3. **How** can exceedance of these ‘thresholds’ be delayed or avoided?

- by mitigation
- by adaptation

\[ \text{best in combination} \]
An amount of $C_\Delta (T,P, \text{etc})$ present future $C_\Delta 1$ threshold $T_1$ timing of exceedance

present

future
Increase resilience of system / sector = raise threshold
= delay time of exceedance
Ability to act is currently available
Increase resilience AND reduce emissions
Adaptation buys time for mitigation
Type of ‘threshold’:

1. So far, have considered key vulnerabilities under incremental climate change

   \[ C_\Delta \text{ and impact} \]

   ( = “Type 1”)

   time

2. Also: tipping points in climate system, e.g.
   - THC, WAIS, Greenland ice sheet
   ( = “Type 2”)

More known about 1 than 2
Conclusions (1):

• Determination of key impacts / thresholds is effected by:
  – what scale: global, regional, local
  – what system or sector
  – what adaptive capacity is assumed, which is dependant upon:
    • what development pathway
Conclusions (2):

Scientific aspects of ‘dangerous’ effects:

1. Effects on systems behaviour; e.g.
   a) non-linear; multiplying
   b) cascading between systems
      i) vertically (e.g. yields → food → hunger)
      ii) horizontally (e.g. water → food → health)

2. Exceeding coping range, e.g.
   a) irreversibilities
   b) beyond current adaptation / tolerance
      - current technical limits
      - current management capacity
Conclusions (3):

Indications are:

• Stabilisation at 750 does not avoid most “dangerous” effects.

• Stabilisation at 550 does avoid most, but at considerable cost (= c.20 times Kyoto reductions).

[N.B. Stabilisation at 400ppm avoids dangerous effects. Recent reports: IPPR report indicates 2°C key vulnerabilities, in circa 2025 given current forcing (WWF)].

• In avoiding ‘dangerous climate change’ choice of development pathway maybe just as important as a specific mitigation strategy, e.g. B2-type development pathway may help avoid/delay much that is “dangerous”.

KEY QUESTIONS FOR THIS MEETING:

✓ What information is available regarding the scientific basis for targets to avoid dangerous effects from climate change?

✓ What would be lost / protected at different levels in different regions and when?

✓ Can we do a better job of assessing economic / biophysical damages and costs?

✓ What are the trade-offs between mitigation and adaptation?
UN Framework Convention on Climate Change

**Ultimate objective (Article 2):**

'...stabilization of greenhouse gas (1) concentrations in the atmosphere at a level that would prevent (2) dangerous anthropogenic interference with the climate system.

Such a level should be achieved within a time frame sufficient
- to allow (3) ecosystems to adapt naturally to climate change,
- to ensure that (3) food production is not threatened and
- to enable economic (3) development to proceed in a sustainable manner.'

**Emissions pathways**

- **(1) Critical concn levels**
  - (global temperature)
- **(2) Critical Limits & thresholds**
  - (regional climate changes)
- **(3) Key Vulnerabilities**
  - (socioeconomic factors, limits to & cost of adaptation)
Changes in river runoff from the present day to the 2080s

Unmitigated emissions

Arnell, 2001, UK Defra

Stabilisation of CO₂ at 750 ppm
Stabilisation of CO₂ at 550 ppm

Change in annual runoff (%)
Changes in crop yield (5 main staple cereals) from the present day to the 2080s

**Potential change in cereal yields (%)**

- 10 – 5
- 5 – 2.5
- 2.5 – 0
- 0 – -2.5
- -2.5 – -5
- -5 – -10
- -10 – -20
- No data

- **Unmitigated emissions**
- **Stabilisation of CO₂ at 750 ppm**
- **Stabilisation of CO₂ at 550 ppm**

Parry, et al. 2001, UK Defra
Ecosystems - Non-Market Impacts

- **Leemans and Eickhout** (2004) using IMAGE estimate area shifts by ecosystem, biodiversity and ability to adapt for 1, 2 and 3°C GMT increase by 2100
- Look across multiple indicators:
  - negative biodiversity and dispersion impacts along side of positive net ecosystem productivity at low levels of change
- Rate of Temperature change a key driver
- Some ecosystem types more vulnerable than others
  - forests especially unable to adapt to rapid change
  - wooded tundra (replaced by boreal forests) in 21st century even at low levels of GMTI
- Conclude that even low levels of change pose significant risk of ecosystem disruption and loss
Agriculture, terrestrial ecosystem productivity and forestry: some general conclusions

At global level, show positive impacts at low levels of climate change, turning to negative and increasing damages at higher levels of climate change

• These findings generally have limited treatment of:
  – changes in extreme events
  – interactions with other “sectors” e.g. irrigation and other water infrastructure investment shifts
  – ecosystem & human system dynamics (e.g. ability of forests and farmers to adapt)

• Baseline, adaptation assumptions vary as do GCM/climate drivers
Regional aggregate damage curves for regions (weights are based on population or projected 2100 regional output)

Changes in water stress from the present day to the 2080s

Billions of people

Decreased water stress      Increased water stress

Unmitigated Emissions    750 ppm Stabilisation    550 ppm Stabilisation

Arnell, 2001
UK Defra
• Thresholds vary not only by system, but also by region and scale.

• Some thresholds have been exceeded ‘now’.
The Shortfall in Global Cereal Production for Reference Case and the SRES Scenarios
Annual average people flooded (Nicholls, 2004) with evolving protection.
Avoiding ‘dangerous effects of climate change’: Extent & nature of current information

- Key vulnerabilities: *long lists available*
- Probabilistic approach: *progress*
- Valuation of damages: *sketchy*
- Potential for (and limits to) adaptation: *very important, but few solid numbers*
A2 in 2050s

- Pop 11.3 billion
- GDP 82 tr $
- primary energy 970 GJ/yr
- carbon 16 GtC/yr

B2

- Pop 9.3 billion
- GDP 110 tr $
- primary energy 870 GJ/yr
- carbon 11 GtC/yr