

Estimating Global Impacts from Climate Change

Presented to:

OECD Workshop on Benefits of Climate Policy
Paris, France

Presented by:

Joel Smith
and
Sam Hitz
Stratus Consulting Inc.
Boulder, Colorado, USA

December 12-13, 2002

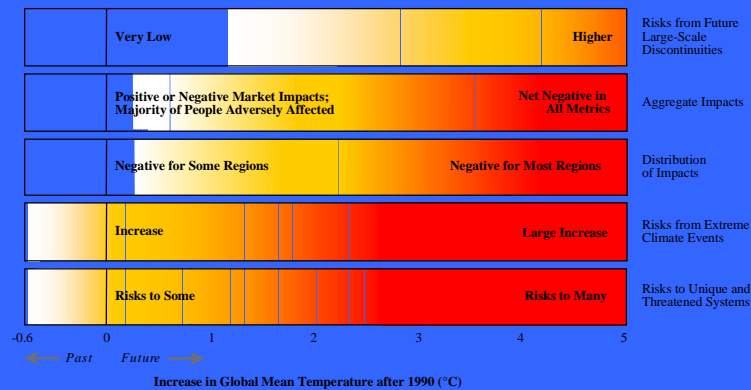


Objective

- Identify relationship between global impacts and different levels of climate change
 - Key issue is identification of marginal global impacts at increasing magnitudes of climate change
 - i.e., what are the shapes of the global impacts curves?



REASONS FOR CONCERN (IPCC, 2001)



Approach (I)

- We surveyed published sectoral studies that quantify the global impacts of climate change
 - Limited ourselves to global studies; did not examine regional impacts literature
- Global mean temperature (GMT) was used as indicator of climate change
 - Recognize the many caveats with doing so
- Characterized the relationships between climate change and sectoral impacts based on study results
 - Increasing impacts
 - Parabolic (quadratic)
 - Indeterminate



Approach (II)

- Used equilibrium (generally older studies) and transient (generally newer studies) results.
- Used metrics employed by authors of individual studies. No attempt to aggregate across studies.
- Identified key factors and assumptions in these studies that could substantially affect results
 - Inclusion and correctness.



LIMITATIONS



Sectors Affected by Climate Change

Published Studies

- Agriculture
- Sea level rise
- Water resources
- Human health
- Terrestrial ecosystems
- Forestry
- Marine ecosystems
- Biodiversity
- Energy

No Global Studies

- Recreation and tourism
- Transport
- Building
- Insurance
- Human amenity



Limitations

- Did not consider:
 - Impacts of temperature changes in excess of 1.4 to 5.8°C range considered likely by Houghton et al., 2001
 - Change in climate variance
 - Impacts due to long term (i.e., post 2100) climate change
 - Potential large scale singular events (e.g., collapse of THC or WAIS)
 - Interaction among impacts on different sectors (e.g., water and agriculture)
 - Ancillary benefits and proactive adaptation



Limitations

- Also:
 - Adaptation generally handled with simplistic assumptions
 - Can over- or underestimate impacts
 - Assumptions about population and development not consistent
 - Development can make substantial difference in vulnerability of societal sectors



Presentation

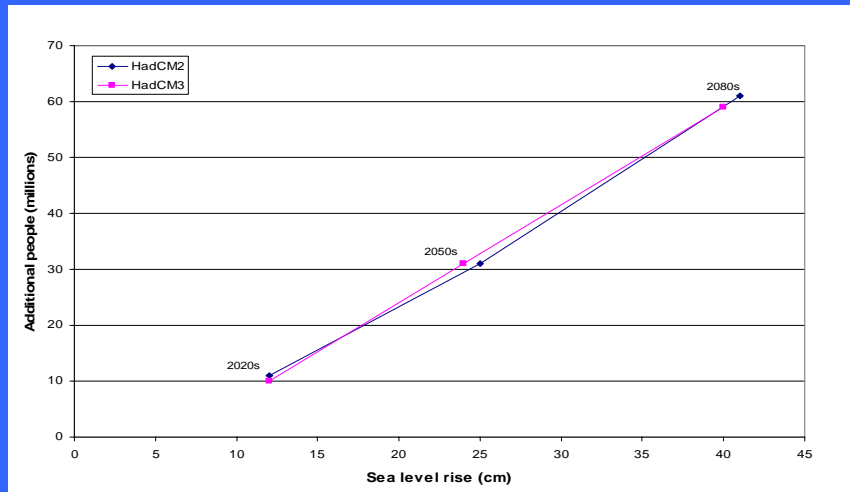
- Results from coastal resources, biodiversity, agriculture, and water sectors are representative of these categories.



Coastal Resources

Nicholls et al., 1999

Additional People in Hazard Zone as a Function of SLR



Coastal Resources Conclusions

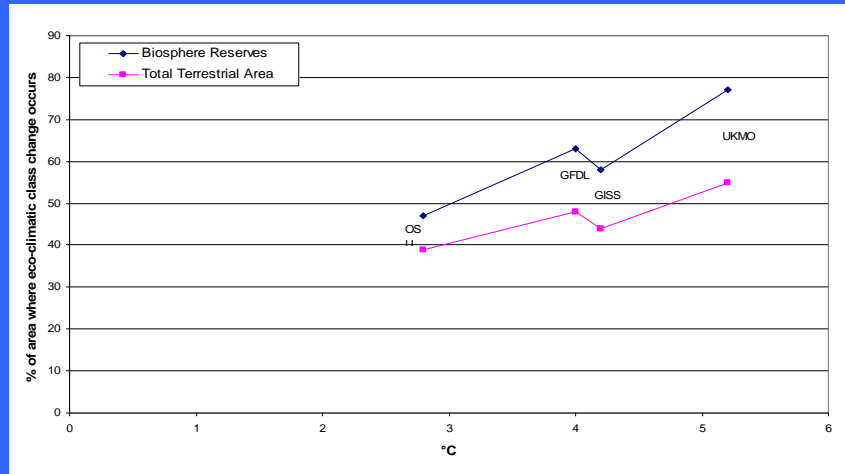
- Adverse impacts seem to increase linearly with SLR (up to 0.5 m).
- This result is in line with expectations of monotonically rising impacts.
- These impacts likely to continue accruing well into following centuries, as sea level continues to rise, even after CO₂ stabilizes.



Biodiversity

Halpin, 1997

Percent Change in Eco-Climatic Classes for Biosphere Reserves
Compared to Global Average



Biodiversity

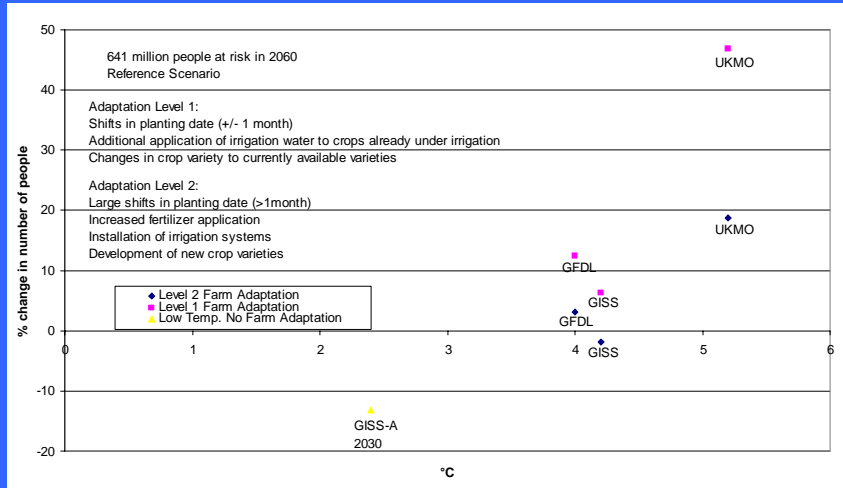
- Eco-climatic classes change more within global bio-reserves as GMT rises.
- There is little reason to doubt this result. It would be difficult to argue that climate change will slow the loss of threatened and endangered species.
- This is mentioned because the loss of individual species or ecosystems is frequently mentioned as an adverse outcome of climate change.



Agriculture

Rosenzweig et al., 1995

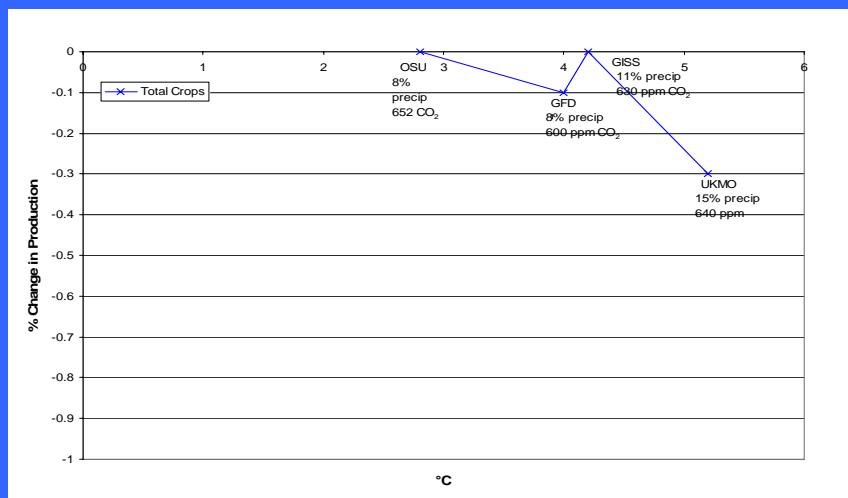
Percent Change in Number of People at Risk of Hunger (2060)



Agriculture

Darwin et al., 1995

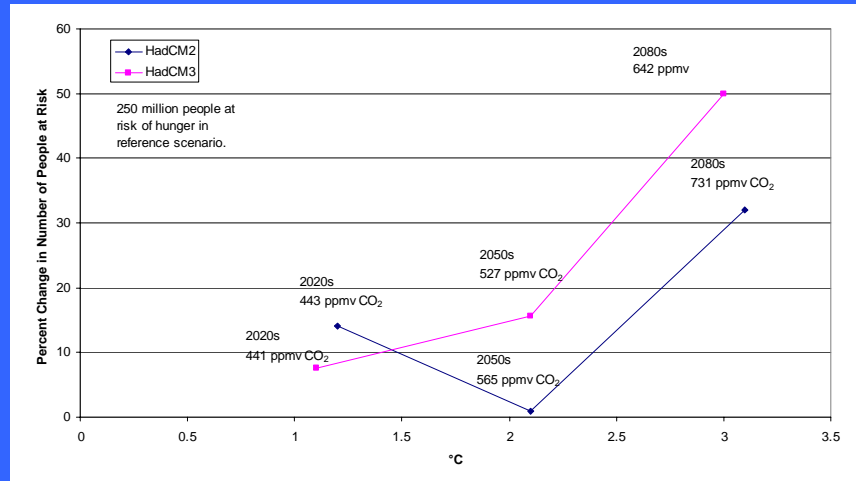
Percent Change in Total Crop Production



Agriculture

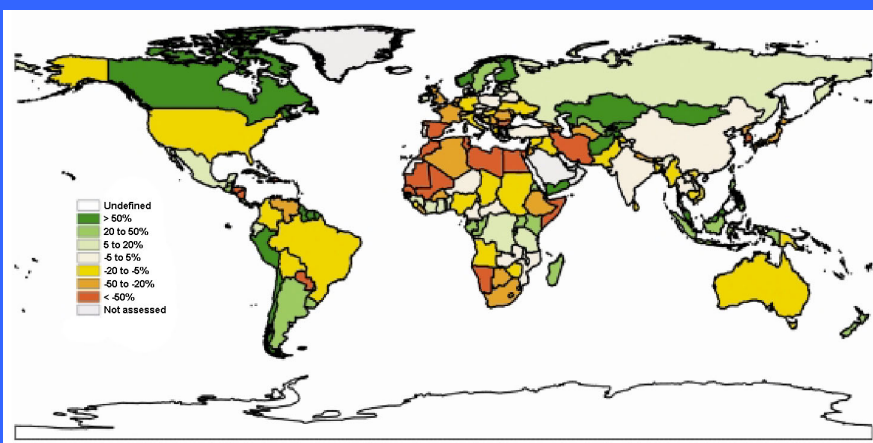
Parry et al., 1999

Percent Change in Number of People at Risk of Hunger



Country Level Climate Change Impacts on Rain Fed Cereal Production Potential on Currently Cultivated Land (HadCM3-A1FI, 2080s)

Fischer et al., 2002



Agriculture Conclusions

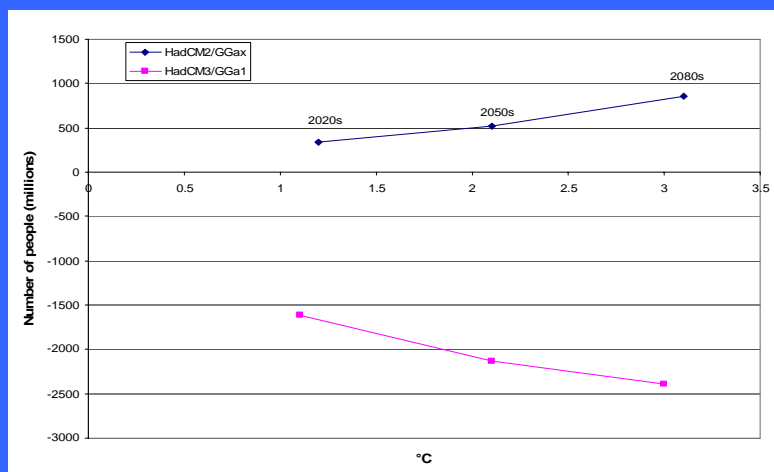
- Results suggest initial increases that eventually become decreases as GMT rises, or alternatively, initial adverse impacts that remain relatively low before rising.
- Some disagreement at lower temperatures, but eventually net reductions beyond 3-4°C.
 - Marginal adverse impacts below that
- Regional results vary considerably.
- This result agrees with expectation based on underlying biophysical processes.



Water Resources

Arnell, 1999

Difference between Total Population in Countries Where Water Stress Increases and Countries Where Water Stress Decreases

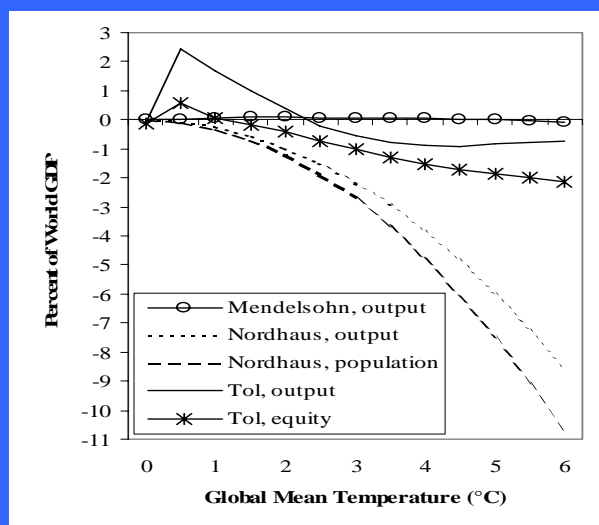


Water Resources Conclusions

- No clear relationship between climate change and impacts on water resources.
- Averaging at the regional or country level presents problems. Basin level is more appropriate.
- Difference in distribution of regional temperature and precipitation is important.
- Metric does not measure intensity of impact.
- We think there will be increasing adverse impacts with increasing GMT.
 - Not (yet) borne out by published literature.



Aggregate Studies



Sectoral Impact Relationships

Table 6. Summary of sectoral damage relationships with increasing temperature.

Sector	Increasing damages ^a	Parabolic	Unknown
Agriculture		X	
Coastal	X		
Water			X
Health			X
Terrestrial ecosystem productivity		X	
Forestry		X? ^b	
Marine ecosystems	X? ^c		
Biodiversity	X		
Energy			X
Aggregate			X

a. Increasing damages means there are damages with small increases in GMT, and the damages increase with higher GMTs. We are unable to determine whether the damages increase linearly or exponentially with GMT.

b. We believe this is parabolic, but with only one study it is difficult to ascertain temperature relationship, so there is uncertainty about this relationship.

c. This relationship is uncertain because there is only one study on this topic.



Conclusions

- Increases in GMT have increasing adverse impacts in many sectors
 - May also have adverse impacts on irreplaceable systems such as coral reefs.
- A 3-4°C rise has net adverse impacts in all sectors.
 - Marginal adverse impacts at lower temperatures
- Aggregate studies we examined tend to be consistent with this conclusion.
- Almost all of the studies show more adverse results at lower latitudes and in developing countries.



Final Caveats

- Changes in key assumptions and simplifications on which each of the studies depend could either lower or raise the temperature range for adverse impact (e.g., adaptation, development, treatment of variability, interaction among sectors, long-term temperature change, or changes in the climate system).
- We should expect significant variation among regional results. The temperature ranges we identify could be quite different depending on the particular combination of regions and sectors.



Some Directions for Further Research

- Analyze sectors with substantial uncertainties: health, water, energy, species diversity
- More analysis of regional sensitivity to increasing magnitudes of climate change
 - particular for developing regions



Aggregation of Impacts is Not the Only Way to Look at Climate Change Risks

From IPCC Synthesis (2001)

