Projections of Climate Change and Some Implications for Ocean Ecosystems

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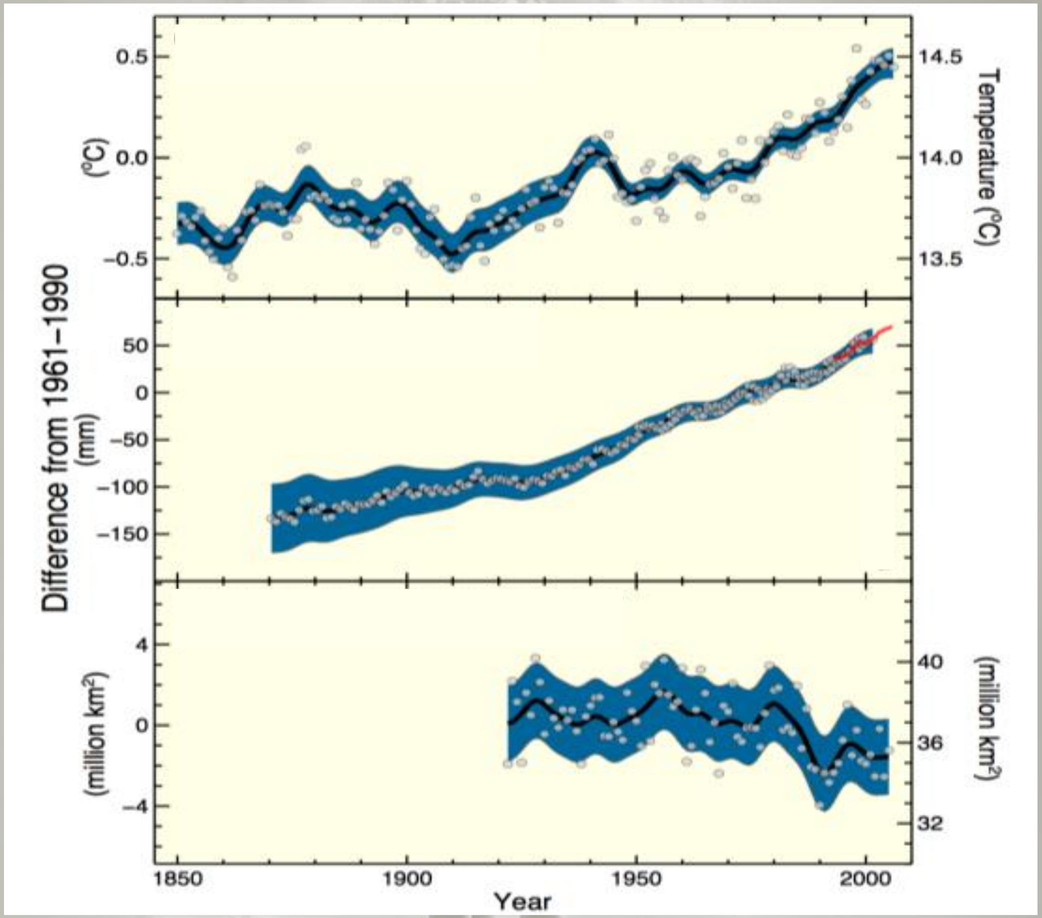
Observed Changes

Global average temperature

Global average sea level

Northern hemisphere snow cover

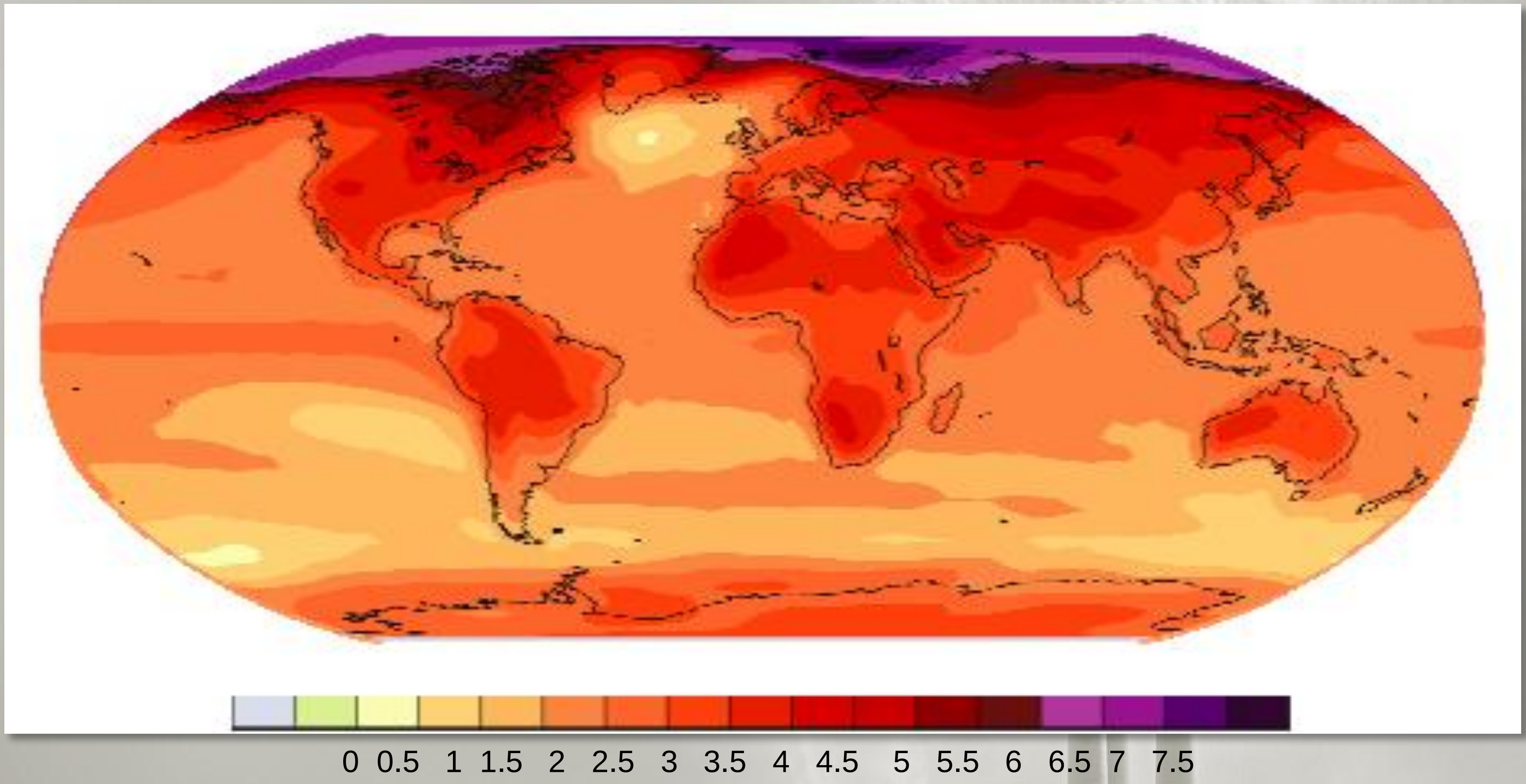


Global average temperature of the ocean since 1961 has increased to depths of 3000m, and the ocean has been taking up over 80% of the heat being added to the climate system.

Source : IPCC

Projected surface temperature changes

2090-2099 relative to 1980-1999



Continued emissions would lead to further warming of 1.1ºC to 6.4ºC over the 21st century (best estimates: 1.8ºC - 4ºC)

Source : IPCC

The Frequency of Heavy Precipitation Events has Increased Over Most Land Areas

Japan experienced serious floods in 2004 due to heavy rains brought by 10 typhoons.

Source : IPCC

Observed effects of climate change

Observed changes in marine and freshwater biological systems associated with rising water temperatures and changes in ice cover, salinity, oxygen levels and circulation :

- Changes in algal, plankton and fish abundance
- Increases in algal and zooplankton abundance
- Earlier fish migrations in rivers

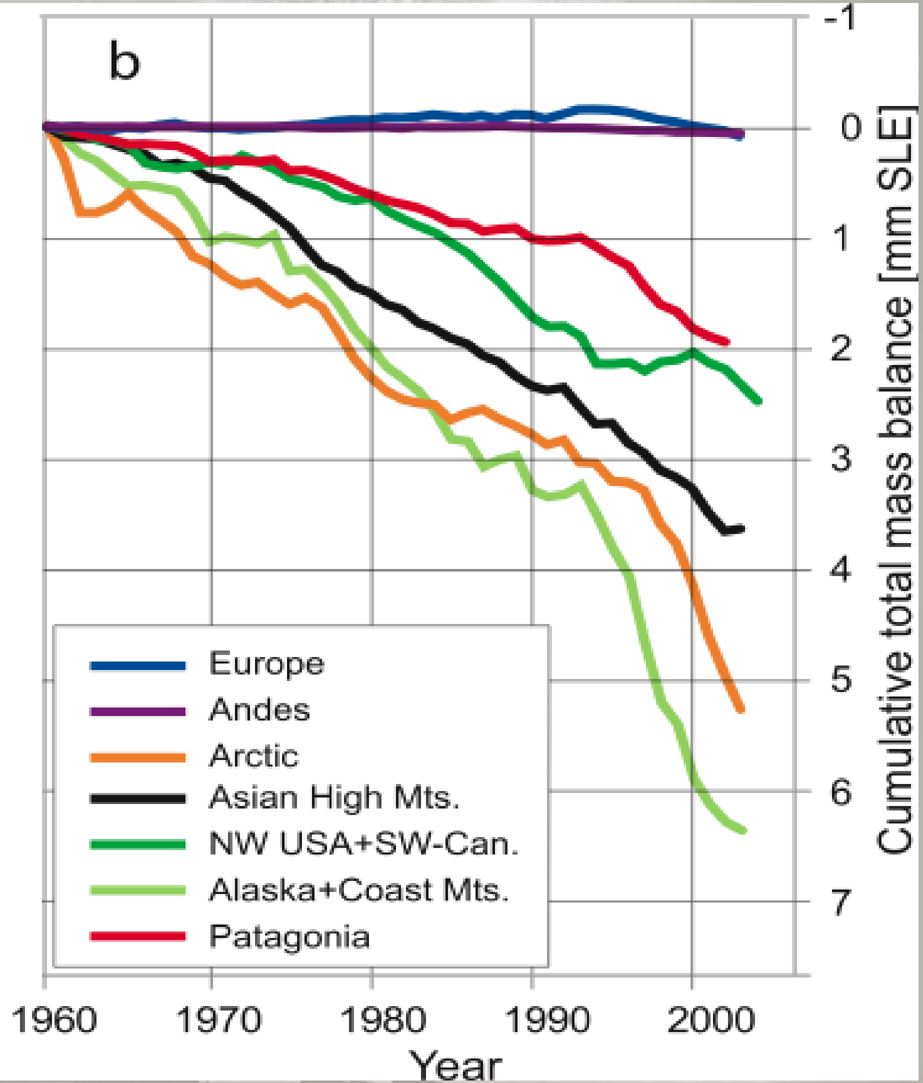
There is increasing evidence of climate change impacts on coral reefs, but separating the impacts of climate-related stresses from other stresses is difficult.

Source : IPCC

Cumulative balance of glacier mass

Since 1993 decreases in glaciers and ice caps has contributed about 28% of sea level rise.
(thermal expansion of the oceans: 57%;
losses from the polar ice sheets: 15%)

New data since the TAR show that losses from the ice sheets of Greenland and Antarctica have *very likely* contributed to sea level rise over 1993 to 2003.

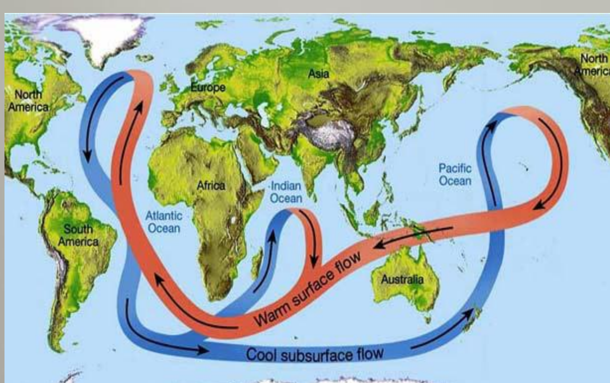


Source : IPCC WGI ch.4 Figure 4.13 *Large-scale regional mean length variations of glacier tongues*

Possible abrupt or impacts

- Partial loss of ice sheets on polar land could imply metres of **sea level rise**, major changes in coastlines and inundation of low–lying areas

- 20–30% of **species** are likely to be at risk of extinction if increases in warming exceed 1.5–2.5° C



- Large scale and persistent changes in **Meridional Overturning Circulation** would have impacts on marine ecosystem productivity, fisheries, ocean CO_2 uptake and terrestrial vegetation

Source : IPCC

Projected regional impacts with global implications

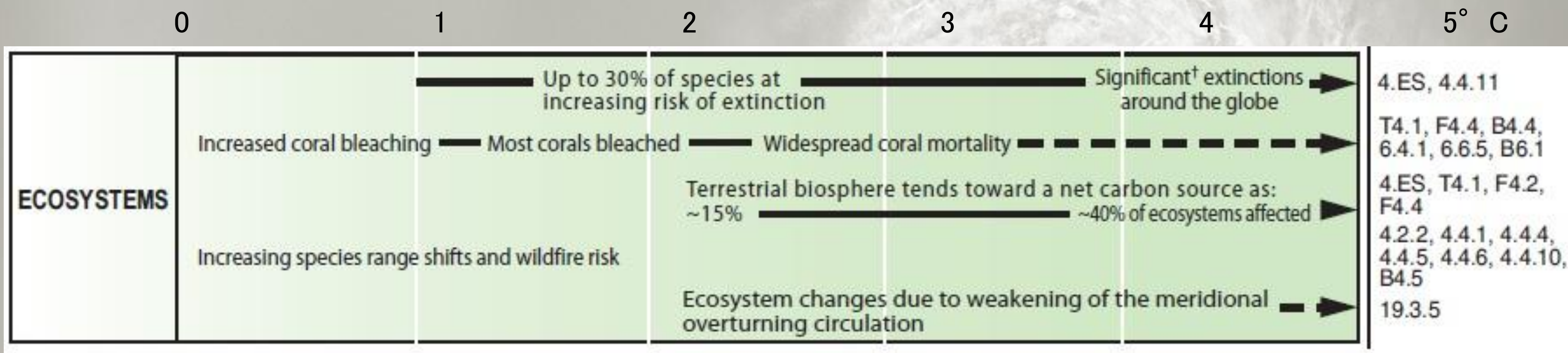
- Disappearance of snow and sea-ice cover may lead to further climate change.
- Retreat of glaciers and ice sheets will alter freshwater runoff, and may influence ocean circulation.
- Increased emissions of carbon from thawing permafrost could lead to positive climate forcing.
- Effects of altered specie-migration patterns due to compromised polar habitats will be felt far beyond the polar regions.
- The Arctic region contains significant amounts of methane hydrates which may be released with warming, adding to GHG concentrations.

We expect climate change in the polar regions to have many direct regional impacts which may have global implications.

Source : IPCC

Examples of impacts associated with global average temperature change
(impacts will vary by extent of adaptation, rate of temperature change and socio-economic pathway)

Global average annual temperature change relative to 1980-1999 (° C)



- Corals are vulnerable to thermal stress and have low adaptive capacity
- Increases in sea surface temperature of about 1 to 3° C could result in coral bleaching and widespread mortality, unless there is thermal adaptation or acclimatization by corals

A 1 to 2° C increase in GMT above 1990 levels poses significant risk to many unique and threatened ecosystems including many biodiversity hotspots.

Source : IPCC Figure 3.6 AR4 SYR

Ecosystems

Coastal and marine ecosystems likely to be especially affected:

- Mangroves and salt marshes due to multiple stresses
- Coral reefs due to multiple stresses
- The sea–ice biome because of sensitivity to warming

In Small Islands, the deterioration of coastal conditions, (through erosion of beaches and coral bleaching), is expected to affect local resources.

The resilience of ecosystems is *likely* to be exceeded this century by an unprecedented combination of climate change and other global change drivers.

Source : IPCC

Ocean Acidification

The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic.

Increasing atmospheric CO2 concentrations lead to further acidification.

The effects of observed ocean acidification on the marine biosphere are as yet undocumented.

But the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g. corals) and their dependent species.

Source : IPCC

Projected impacts

Flooding

- Potential impacts of one metre sea-level rise include inundation of 2,339 km^2 in some big cities of Japan.

Agriculture

- In certain scenarios, rice yield could decrease up to 40% even in irrigated lowland areas of central and southern Japan.

Food security

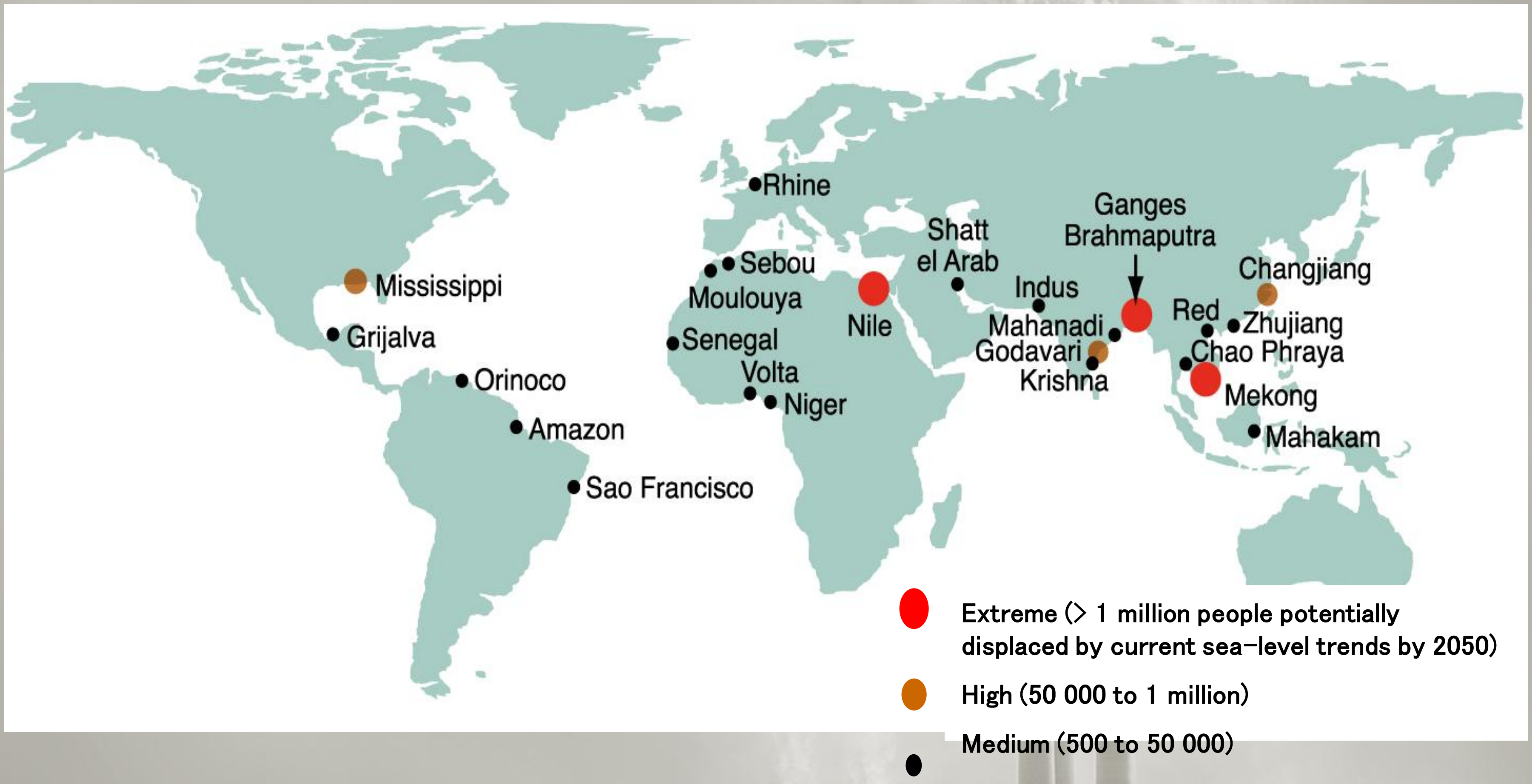
- Net cereal production in South Asia could decline between 4 to 10% by 2100. Changes in cereal crop production potential indicate increasing stress on resources in many of Asia’s developing countries.

Forests

- About 90% of the suitable habitat for one of Japan’s dominant forest species (*Fagus crenata*) could disappear by the end of this century.

Source : IPCC

Vulnerability of coastal zones



Asian megadeltas especially are key societal hotspots of coastal vulnerability

Source : IPCC

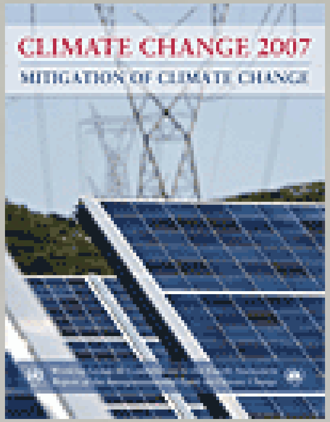
Role and limits of adaptation

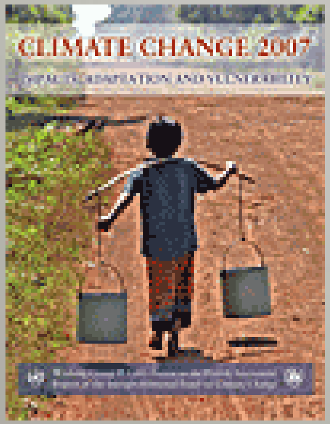
- Societies have a **long record** of adapting to the impacts of weather and climate
- Adaptation is **necessary** to address impacts resulting from the warming which is already unavoidable due to past emissions
- Adaptation to the impacts of climate change & promotion of sustainable development share **common goals**

But adaptation alone is not expected to cope with all the projected effects of climate change

Source : IPCC

Adaptation and Mitigation





“Neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change”

- IPCC Fourth Assessment Report

Source : IPCC

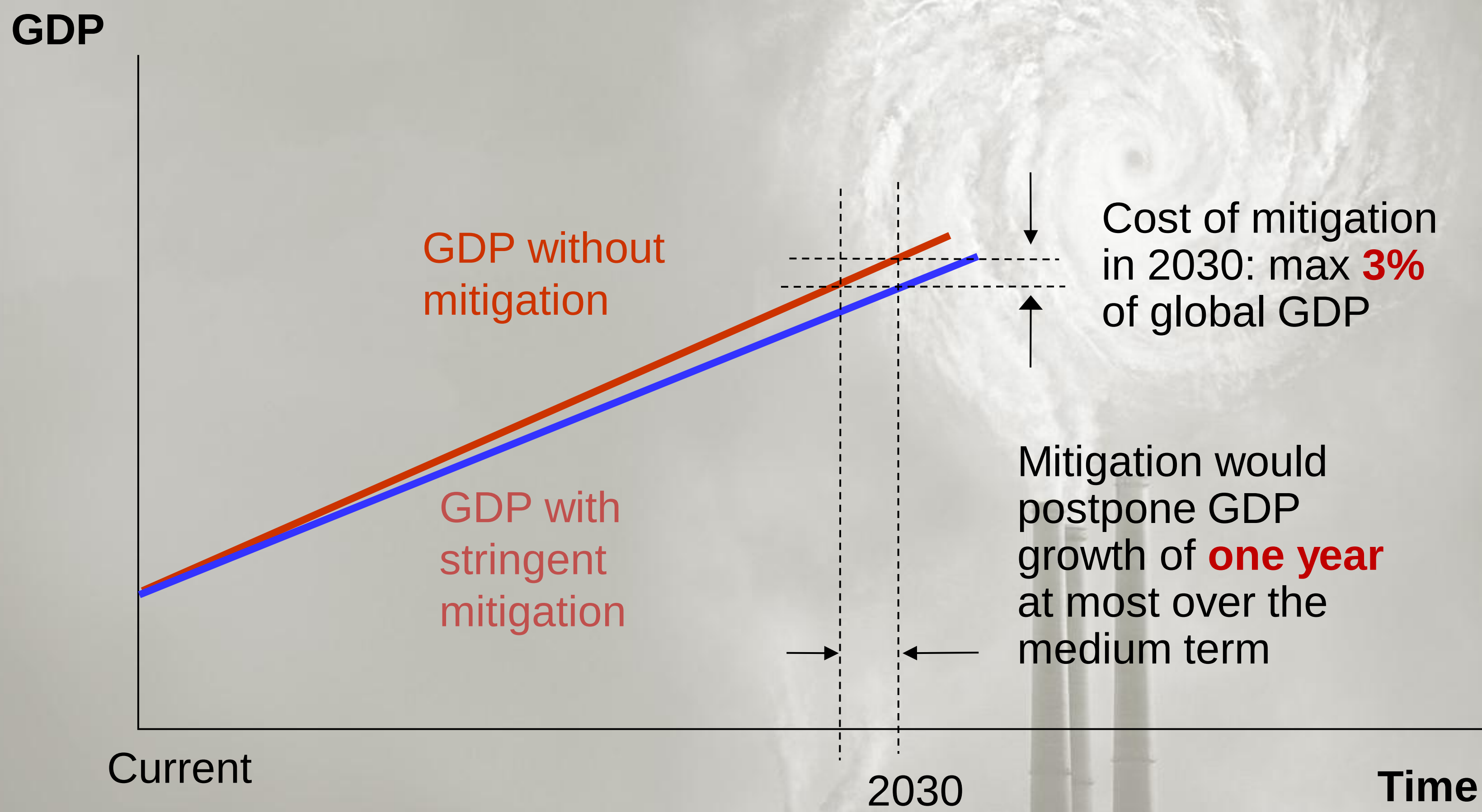
Characteristics of Stabilization Scenarios

Post-TAR stabilization scenarios

Stabilization level (ppm CO2-eq)	Global mean temp. increase (ºC)	**Year CO2 needs to peak**	Global sea level rise above pre- industrial from thermal expansion (m)
445 – 490	2.0 – 2.4	2000-2015	0.4 – 1.4
490 – 535	2.4 – 2.8	2000-2020	0.5 – 1.7
535 – 590	2.8 – 3.2	2010-2030	0.6 – 1.9
590 – 710	3.2 – 4.0	2020-2060	0.6 – 2.4

Source : IPCC

Impacts of mitigation on GDP growth



Source : IPCC

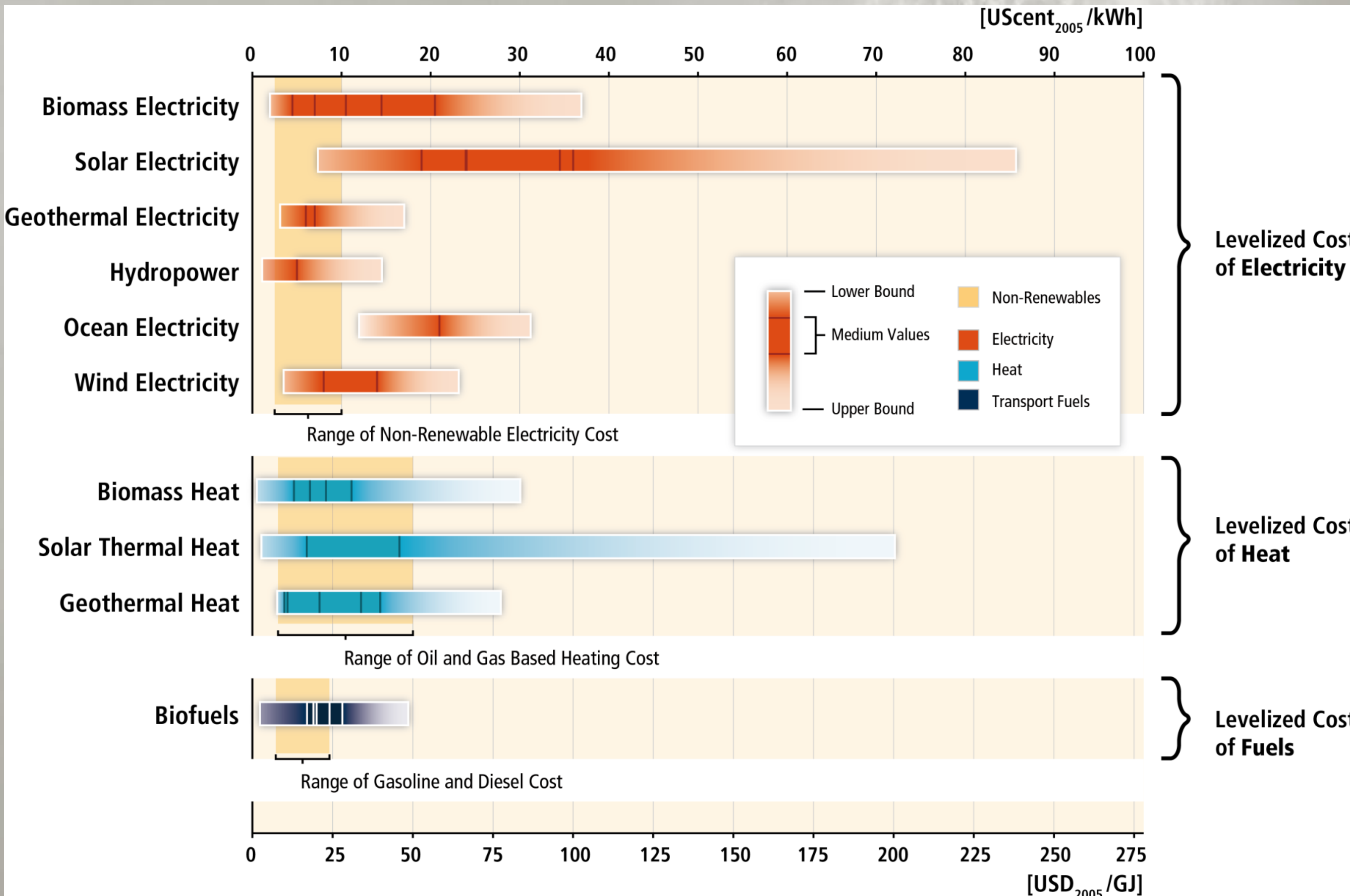
Co-benefits of mitigation

- **Common drivers** lie behind mitigation policies and policies addressing economic development, poverty, health, employment, energy security, and local environmental protection
- **Linking policies** provide the opportunity for no-regrets policies reducing greenhouse gases mitigation costs

CO_2 mitigation potential for 2010 without net cost in India: between 13 and 23% of business as usual scenario

Source : IPCC

RE costs are still higher than existing energy prices but in various settings RE is already competitive.



Source : IPCC SRREN

Overcoming barriers

A **significant increase** in the deployment of RE by 2030, 2050 and beyond is indicated **in the majority of the 164 scenarios** reviewed in this SRREN. However:

- A transition to higher shares of RE would imply increasing investments in **technologies and infrastructure**
- **Policies** play a crucial role in accelerating the deployment of RE technologies.
- Policies include regulations, financial incentives, public finance mechanisms and carbon pricing mechanisms.

'Enabling' policies support RE development and deployment

Source : IPCC SRREN

Ocean Energy

Ocean energy technologies:

- utilize seawater as their motive power
- harness its chemical or heat potential.

Six sources, requiring different technologies for conversion:

- waves
- tidal range
- tidal currents
- ocean currents
- ocean thermal energy conversion (OTEC)
- salinity gradients.

Ocean energy could be used to supply electricity and for direct potable water production or to meet thermal energy service needs.

Source : IPCC SRREN

Potential for ocean energy

- Estimates for theoretical potential for ocean energy well exceed current and future human energy needs.
- technical potentials will vary based on future technology developments.
- Ocean energy systems are at an early stage of development, but technical advances may progress rapidly given the number of technology demonstrations.

Ocean energy has the potential to deliver long-term carbon emissions reductions and appears to have low environmental impacts.

Source : IPCC SRREN

Accelerating implementation of ocean energy technologies

National and regional government policy initiatives :

- R&D and capital grants to device developers
- performance incentives for produced electricity
- marine infrastructure development
- standards, protocols and regulatory interventions for permitting
- space and resource allocation

Successful deployment will lead to cost reductions. Whether these are sufficient to enable broad-scale deployment of ocean energy is the most critical uncertainty in assessing the future role of ocean energy in mitigating climate change.

Source : IPCC SRREN

Japan-India Collaboration in Renewable Energy: MSME

TERI-IGES-JICA "Science and Technology Research Partnership for Sustainable Development" (2010 – 2014)

- Micro, Small and Medium Enterprises (MSME) account for 45% of India's manufacturing output
- The focus of this project is the promotion of low carbon technologies in India's Small and Medium Enterprises
- Identified low carbon technologies include Small Gas and Electric Heat Pumps for heating and cooling applications

Source : TERI

"A technological society has two choices.

First it can wait until catastrophic failures expose systemic deficiencies, distortion and self deceptions…

Secondly, a culture can provide social checks and balances to correct for systemic distortion prior to catastrophic failures"

- Mahatma Gandhi