

# Climate Change: An Overview and Policy Implications

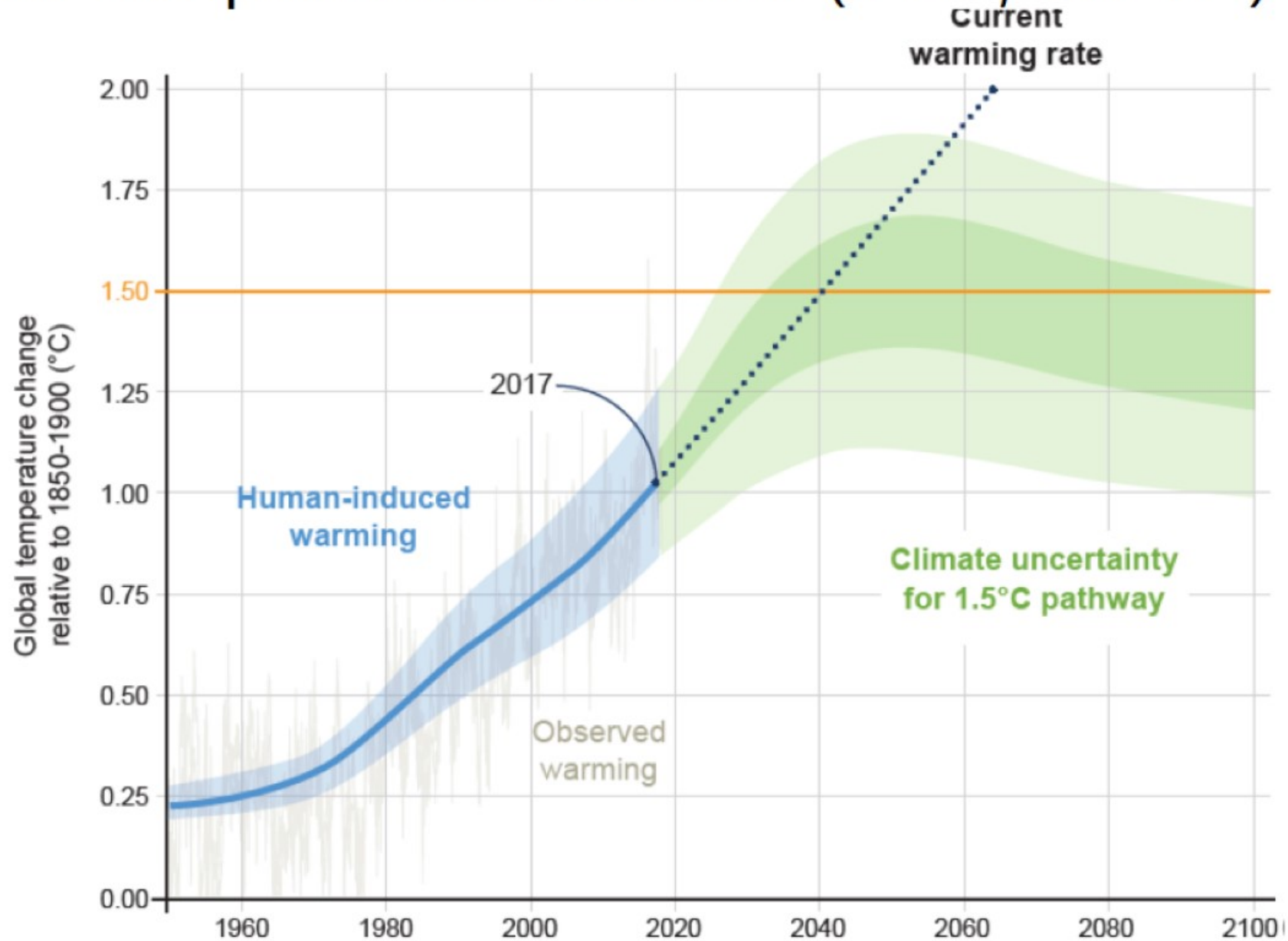
June 2019

Hong-Sang JUNG (KDI School)

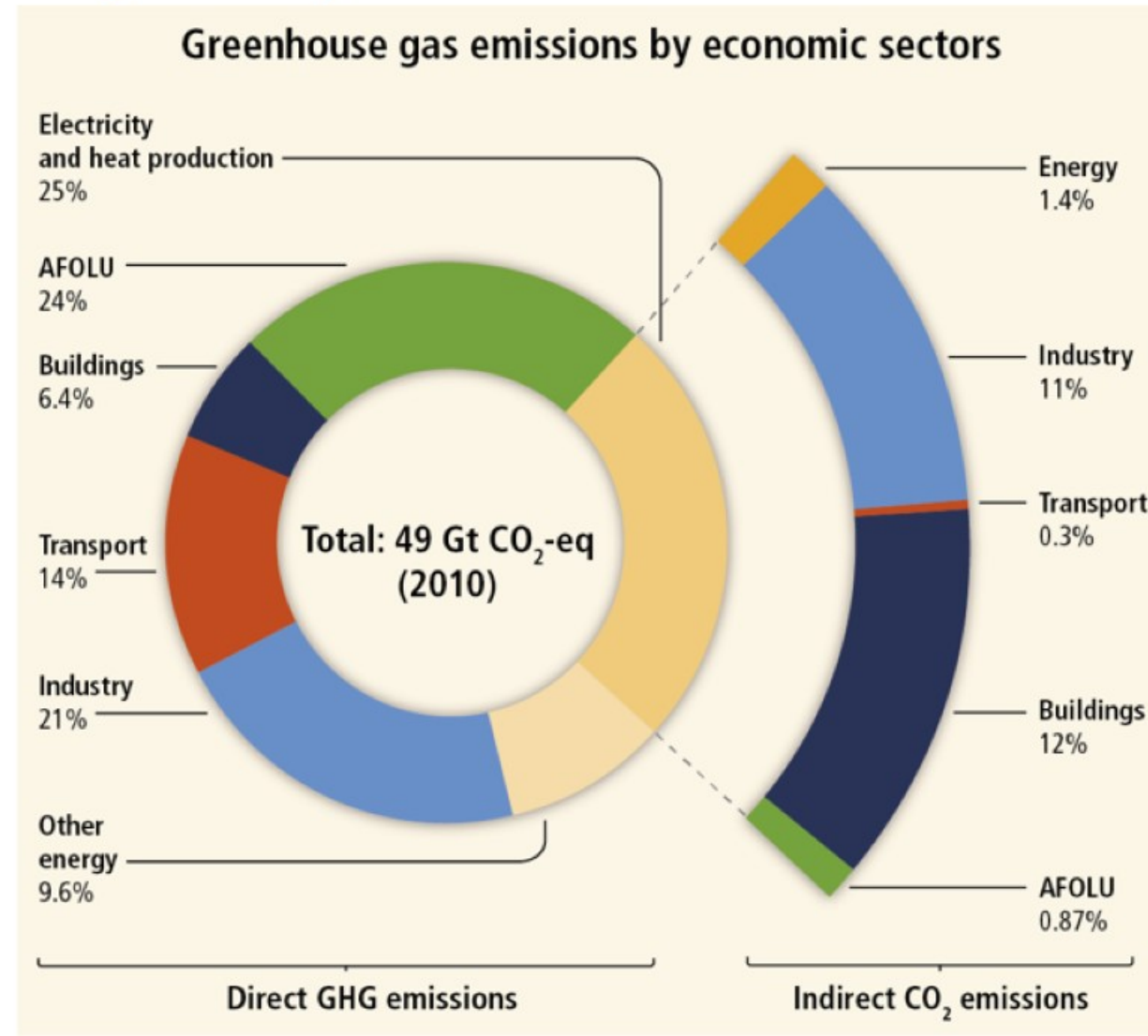
# Contents

- Cause
  - Is the Earth warming?
  - Is it caused by human emission of GHG?
- Impacts
  - What impacts have been made or anticipated?
- Response
  - Are the damages of continued warming well above emission reduction costs?
  - What policies shall be adopted?
  - Why little action has been carried out so far?
- Conclusion

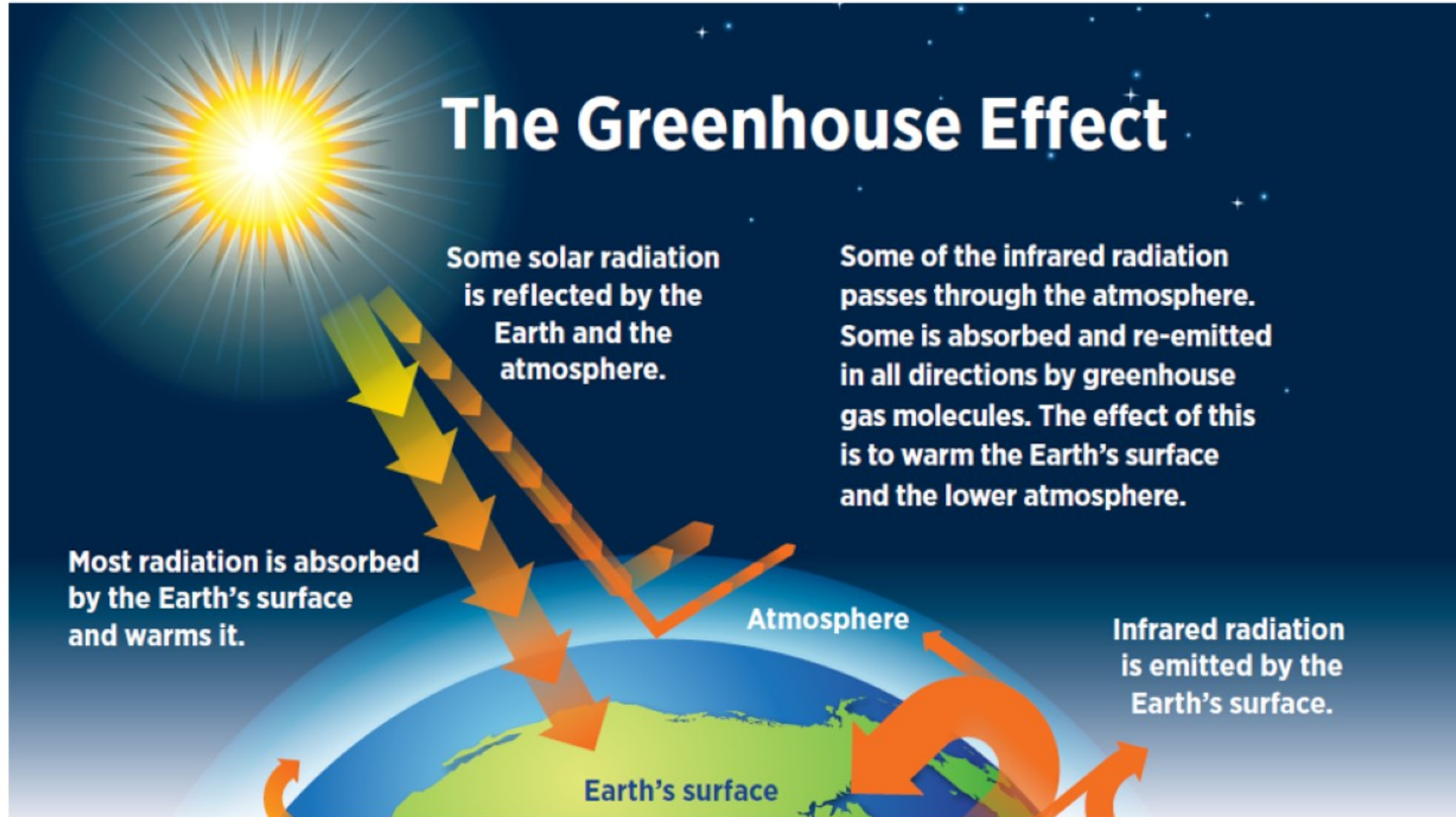
# Global temperature increase (IPCC, SR 1.5)



# Main sources of GHG emissions are burning fossil fuels (IPCC, AR5).



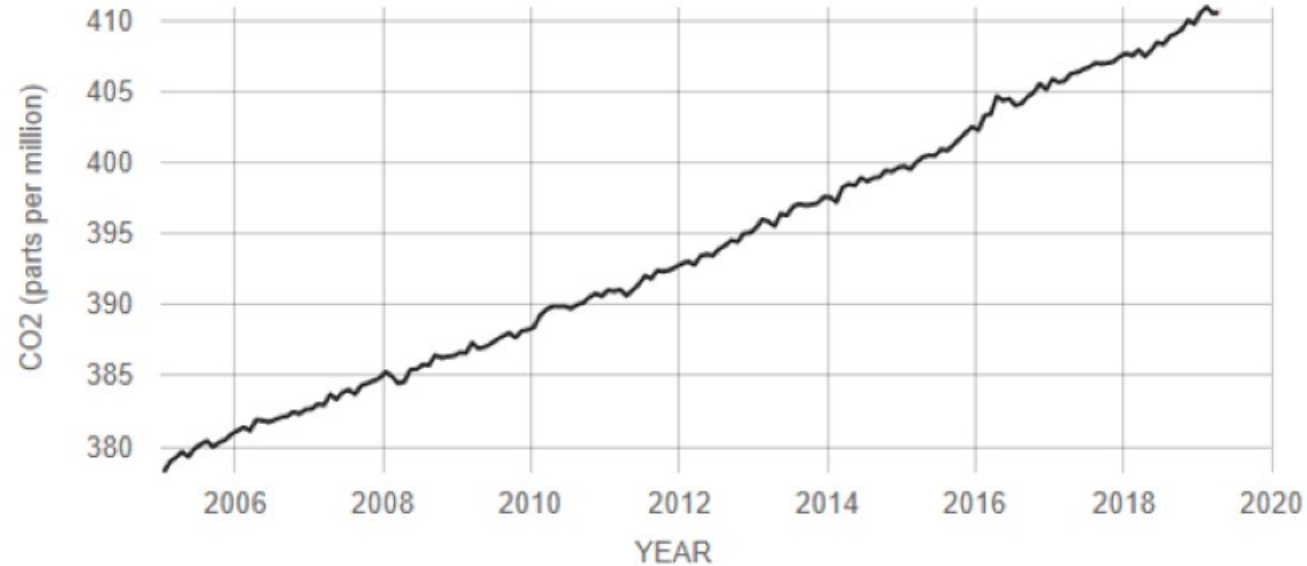
Global warming is driven by GHG emissions.



# Carbon dioxide concentration

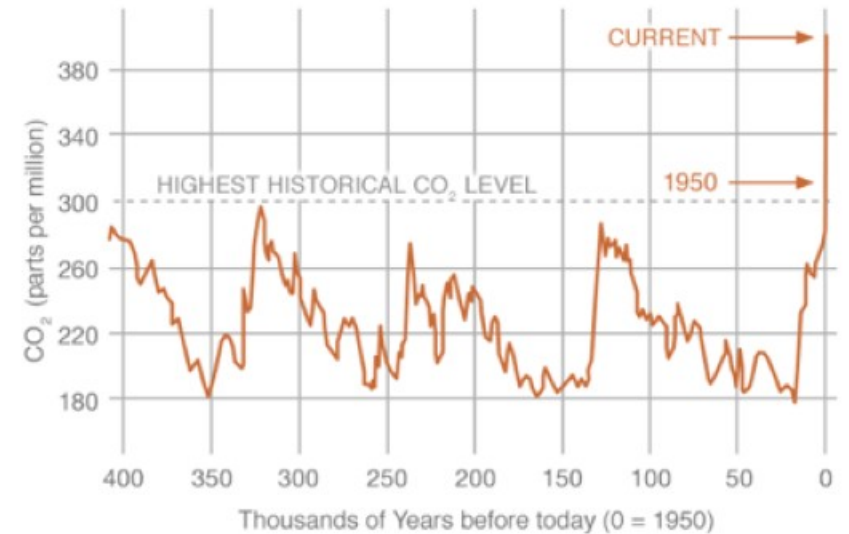
## DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (average seasonal cycle removed). Credit: [NOAA](#)



## PROXY (INDIRECT) MEASUREMENTS

Data source: Reconstruction from ice cores.  
Credit: NOAA



# How reliable is it that human activity is responsible to global climate change?

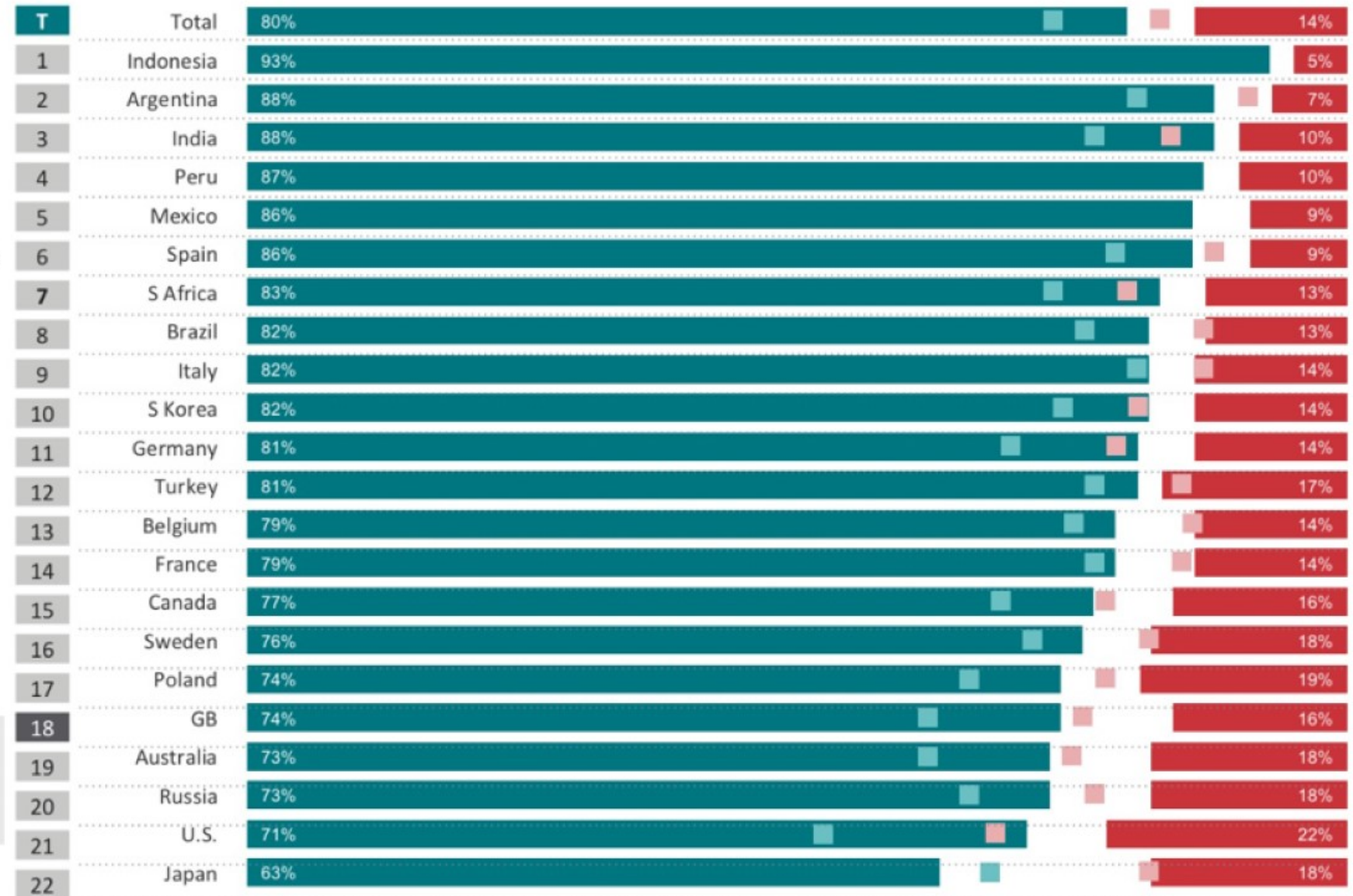
- Almost 200 nation governments acknowledged (IPCC, UNFCCC).
- About 97% of climate scientists agrees.
- About 80% of general public agrees.

## \* Other views

- Climate science is so complex that not even leading climate scientists profess to understand climate change fully.
- Climate change is the rule rather than the exception in the earth's long history. There is natural 1,500-year climate cycle.
- Climate change is mainly due to other factors: e.g., solar variability; volcano eruptions.

To what extent do you agree or disagree with the following statements?

The climate change we are currently seeing is largely the result of human activity

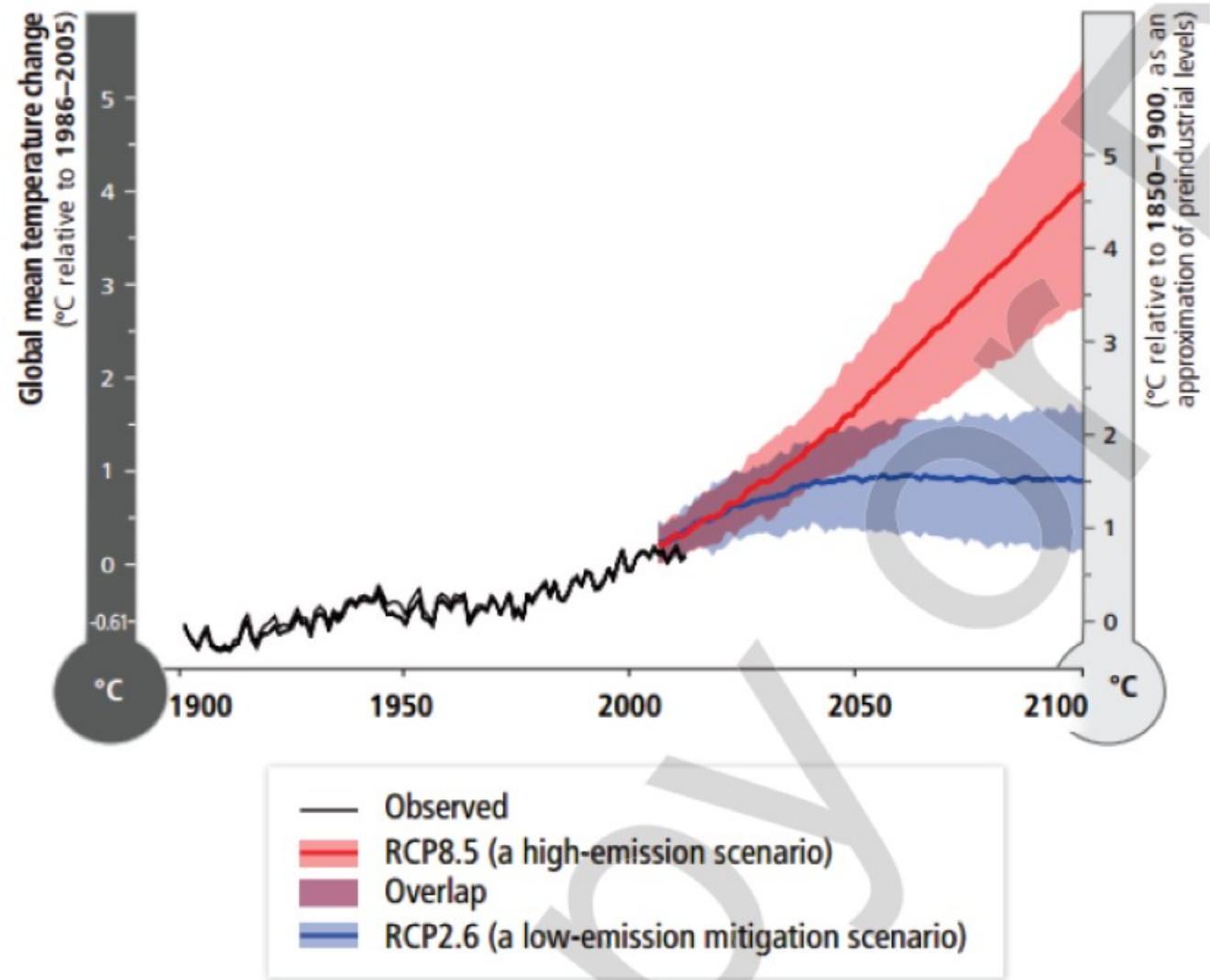


**KEY:**

- Agree 2016
- Disagree 2016
- Agree 2014
- Disagree 2014

# Predicting CO<sub>2</sub> emissions and future climate change is complex and with high uncertainty.

- If no additional efforts to mitigate (IPCC AR5)
  - CO<sub>2</sub> concentration 450 by 2030, 750~1300 by 2100.
  - Global temperature increase 3.7~7.8°C by 2100.
- Source of uncertainties
  - Positive feedback loops.
  - Melting of perma-frost.
  - Future growth, technology change.



# Impacts of climate change

- Sea level rise.
- Frequent extreme weather.
- Pressure on water and food.
- Political and security risks.
- Human health risks.
- Impact on wildlife and ecosystems.

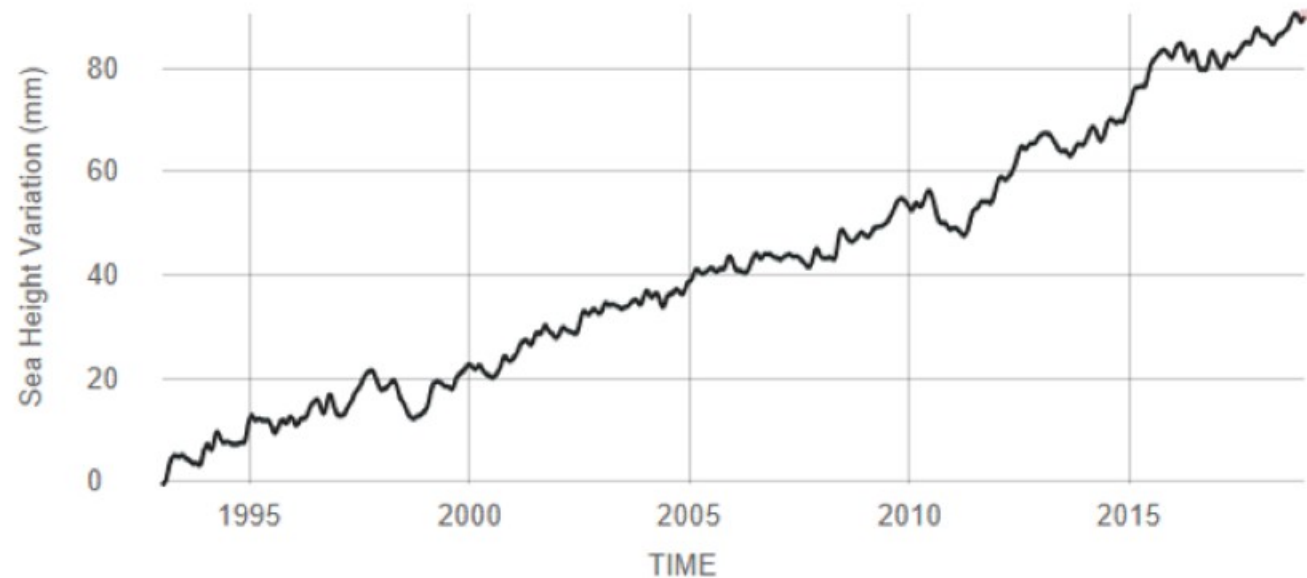
# Sea level rise (NASA)

## SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.  
Credit: NASA Goddard Space Flight Center

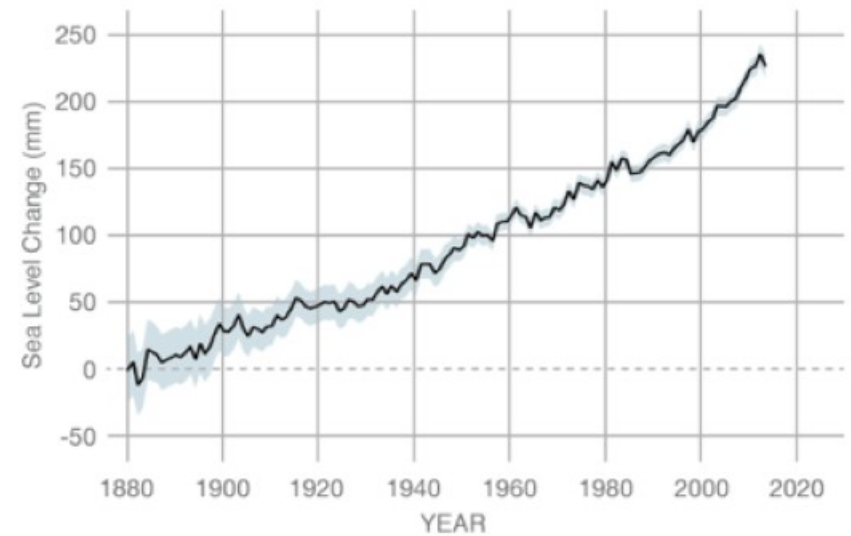
## RATE OF CHANGE

↑ **3.3**  
millimeters per year



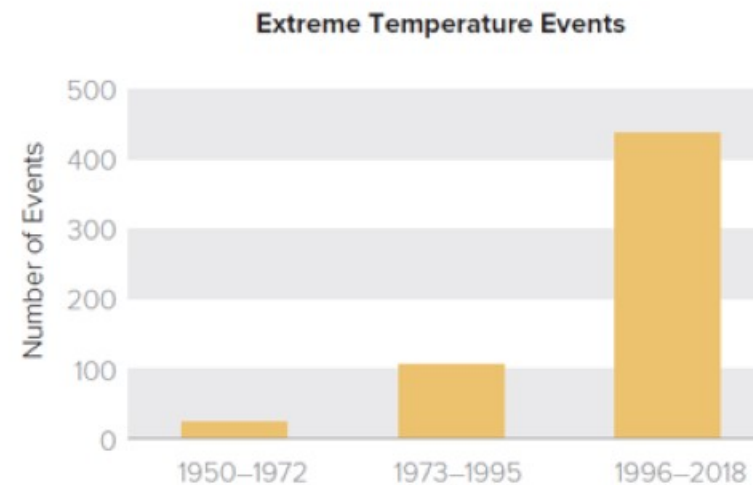
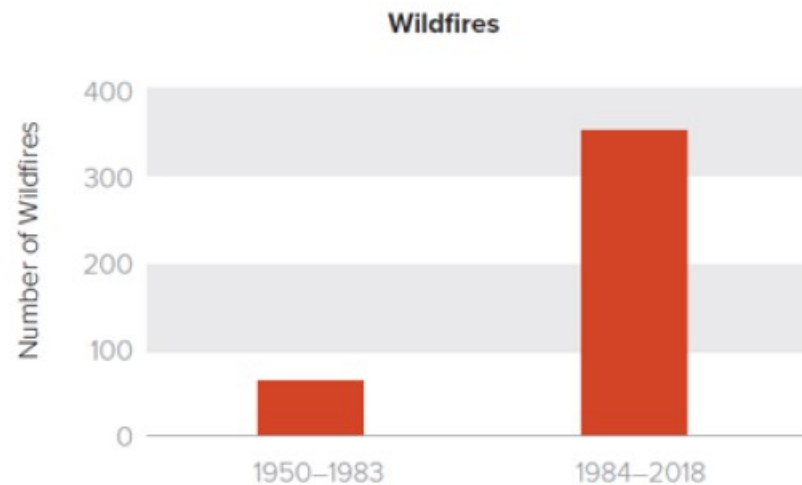
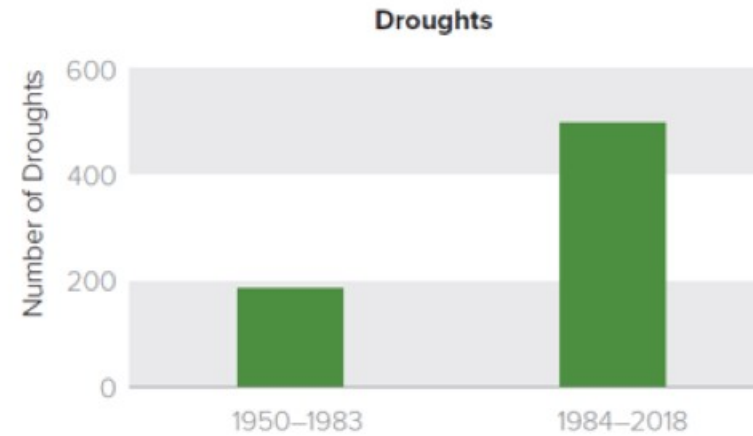
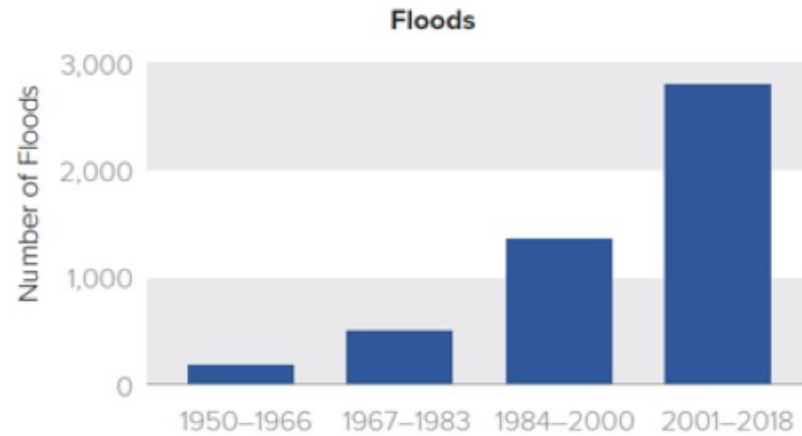
## GROUND DATA: 1870-2013

Data source: Coastal tide gauge records.  
Credit: CSIRO



# Extreme weather events (WRI)

Global Occurrences of Extreme Weather Events.



# Water and food

- Water

- Growing population, rising incomes, and expanding urban areas raise water demand (for food, energy, urban) exponentially.
- The world will face a 40% shortfall of water between demand and available supply by 2030.
- Climate change makes water supply more erratic and uncertain.

- Food

- The world will need to produce about 60 percent more food by 2050 to feed an estimated 9 billion people.
- This challenge is intensified by agriculture's extreme vulnerability to climate change.

# Political and security risks

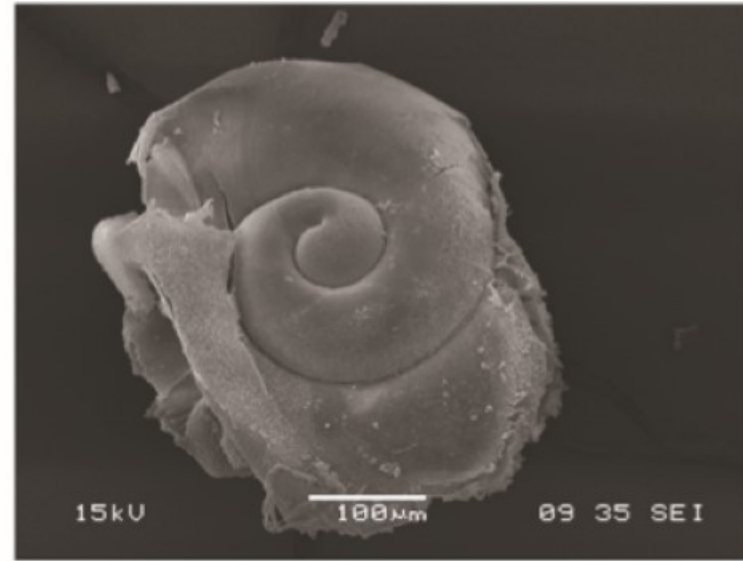
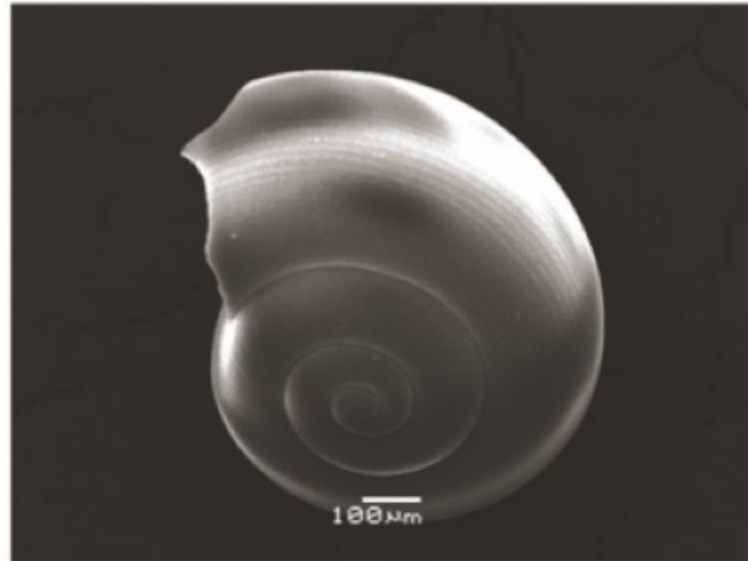
- Food price increase.
  - During food price hike in 2007~8, food riots in Argentina, Cameroon, Haiti, India...
- Drought and famine.
  - Somalian, Syrian civil wars.
- Water shortages.
- Migration needs.

# Human health risks

- Increase the possibility of heat-related injury and death.
  - 70 thousand casualties in the 2003 European heat wave, 50 thousand in the 2010 Russian.
- Water- and vector-borne diseases are projected to increase as insects and other carriers move into higher latitudes.
- Warmer atmosphere increases the concentrations of smog.

# Impacts on wildlife and ecosystems

- Current extinction rates are 100 times the normal rate.
  - 30~50% of land and marine animal species may be extinct by 2100.
- Ocean temperature increase and ocean acidification.
  - The world's coral reefs could be entirely extinct by 2050.

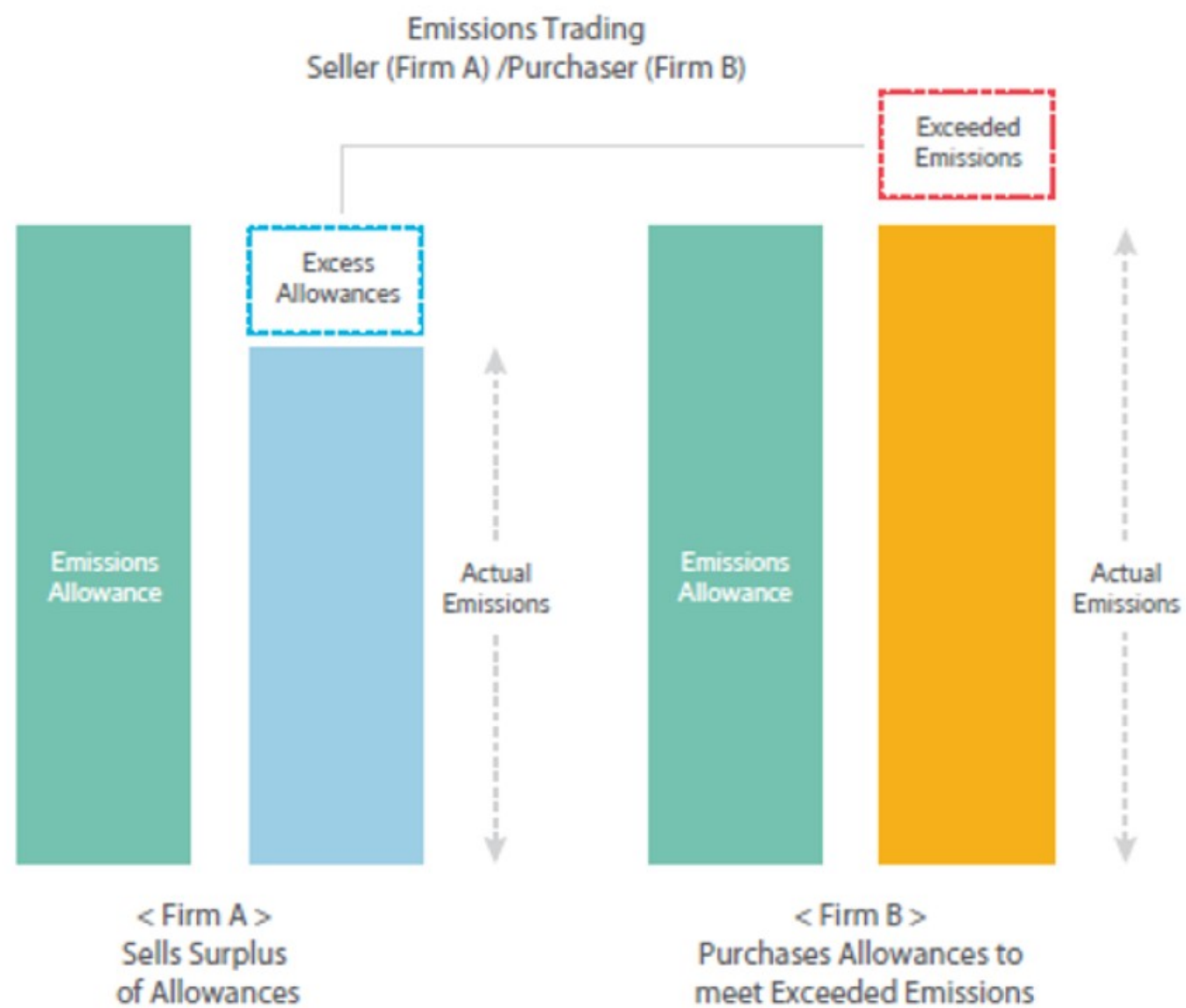


# Responding to climate change

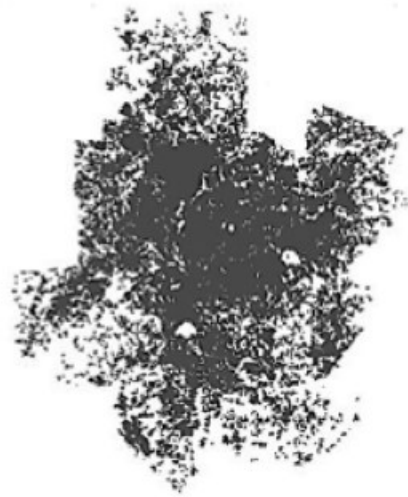
- General agreement: global warming needs to be limited to 2°C above pre-industrial level by 2100.
  - Requires CO<sub>2</sub> concentration to remain below 450 ppm.
- Carbon cutting strategies
  - Improving energy efficiency.
  - Moving away from fossil fuels.
  - Changes in agricultural, forestry, and other land use.
  - CO<sub>2</sub> removal.

# Improving energy efficiency

- A promising means of reducing GHG emissions.
  - Around 40% of the reduction required by 2050 could potentially come from increased energy efficiency (IEA).
- Policy examples
  - Carbon tax or emission trading scheme.
  - Energy efficiency standards and labeling for appliances and products.
  - Encouraging residential density, localized employment opportunities, and public transportation.
  - Behavioral changes like driving smaller cars.



## ATLANTA'S BUILT-UP AREA



0 10 20 (km)

POPULATION:	<b>2.5 MILLION</b>
URBAN AREA:	<b>4,280 KM<sup>2</sup></b>
TRANSPORT	
CARBON EMISSIONS:	<b>7.5</b>
TONNES CO <sub>2</sub> PER PERSON (PUBLIC + PRIVATE TRANSPORT)	

## BARCELONA'S BUILT-UP AREA



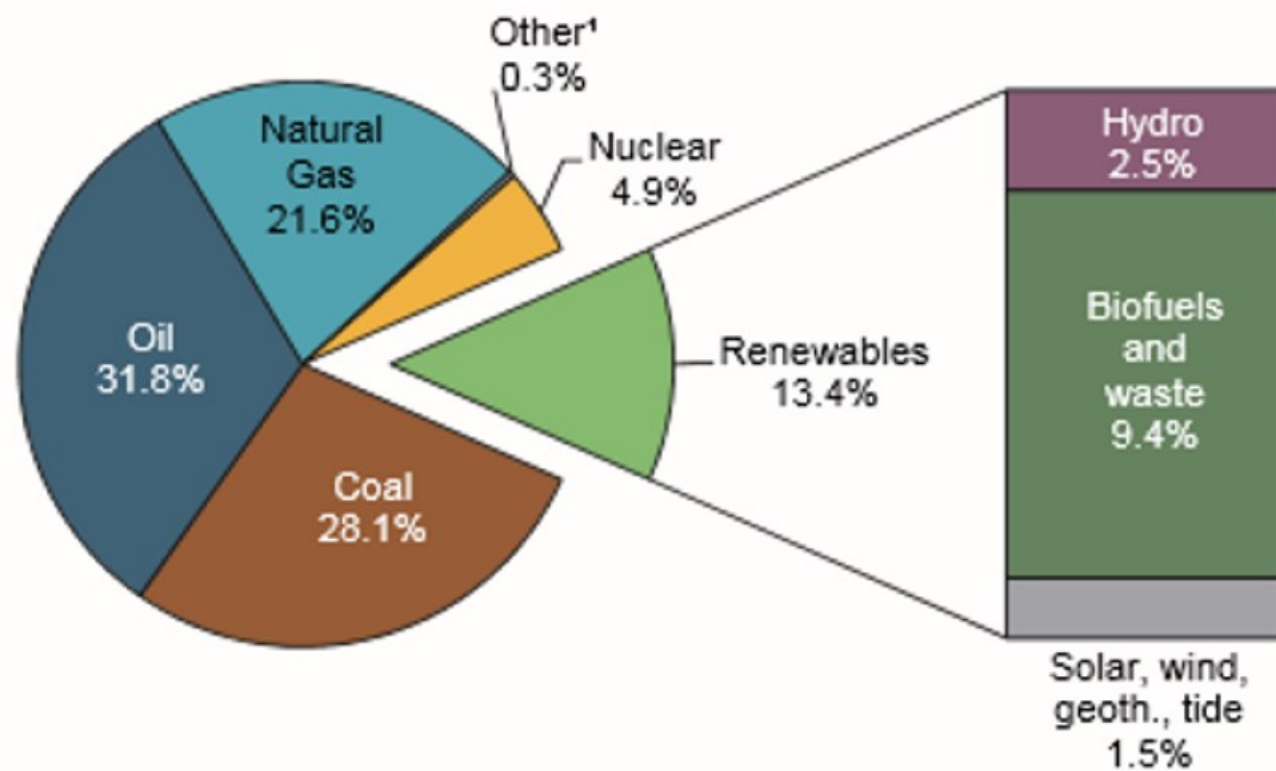
0 10 20 (km)

POPULATION:	<b>2.8 MILLION</b>
URBAN AREA:	<b>162 KM<sup>2</sup></b>
TRANSPORT	
CARBON EMISSIONS:	<b>0.7</b>
TONNES CO <sub>2</sub> PER PERSON (PUBLIC + PRIVATE TRANSPORT)	

# Moving away from fossil fuels

- Energy supply transitioning from coal, oil, and natural gas.
  - Toward hydro, solar, wind, and nuclear power.
- Solar and wind energy still needs technology improvements.
  - Are they economically competitive against fossil fuels?
  - Solar and wind cannot provide baseload (continuous) power, requiring significant advances in energy storage and in smart grid.
- Transportation sector mostly depends on oil.
  - Shifting to biofuels, promoting electric vehicles.

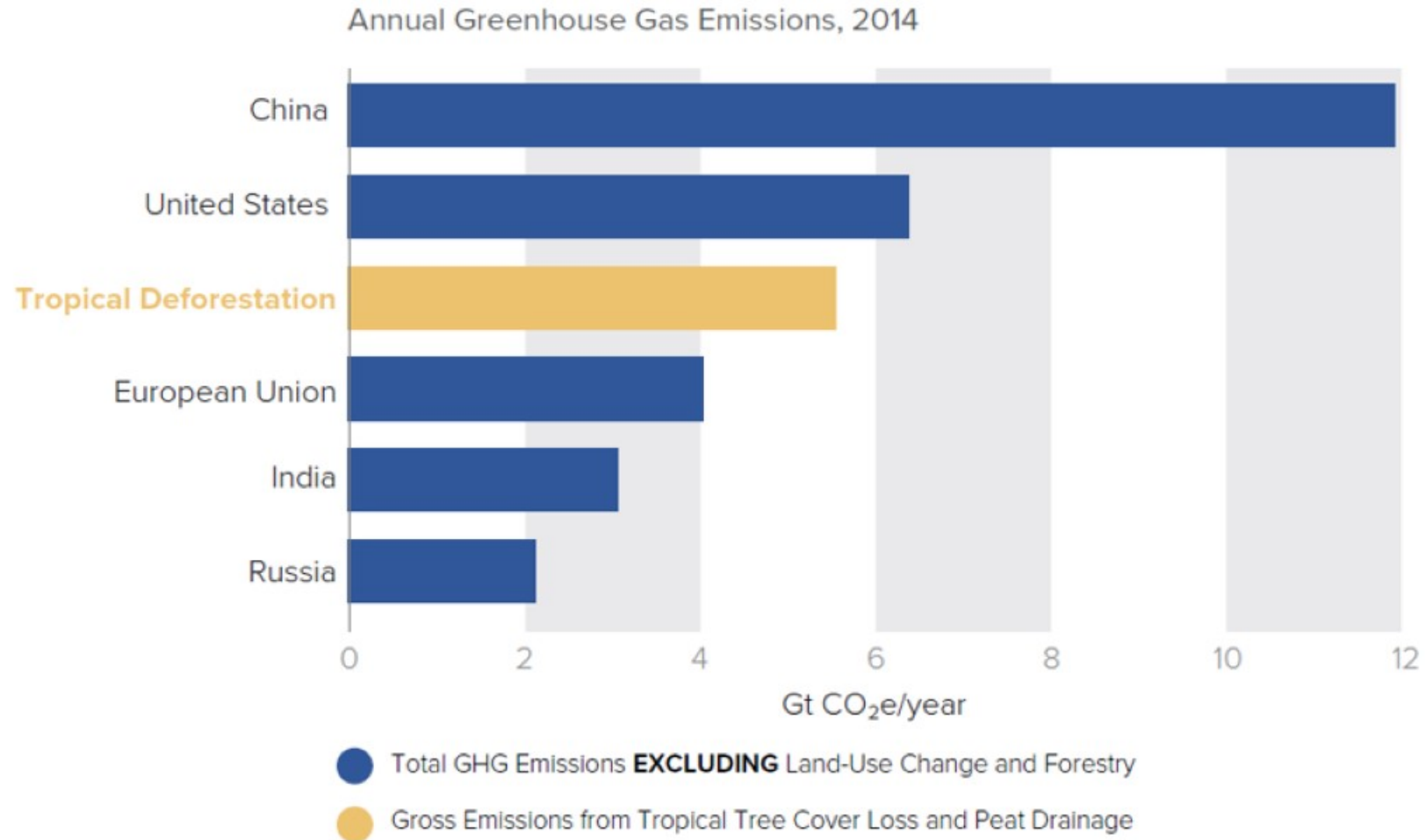
**Figure 1: 2015 fuel shares in world total primary energy supply**



# Changes in agricultural, forestry, and other land use

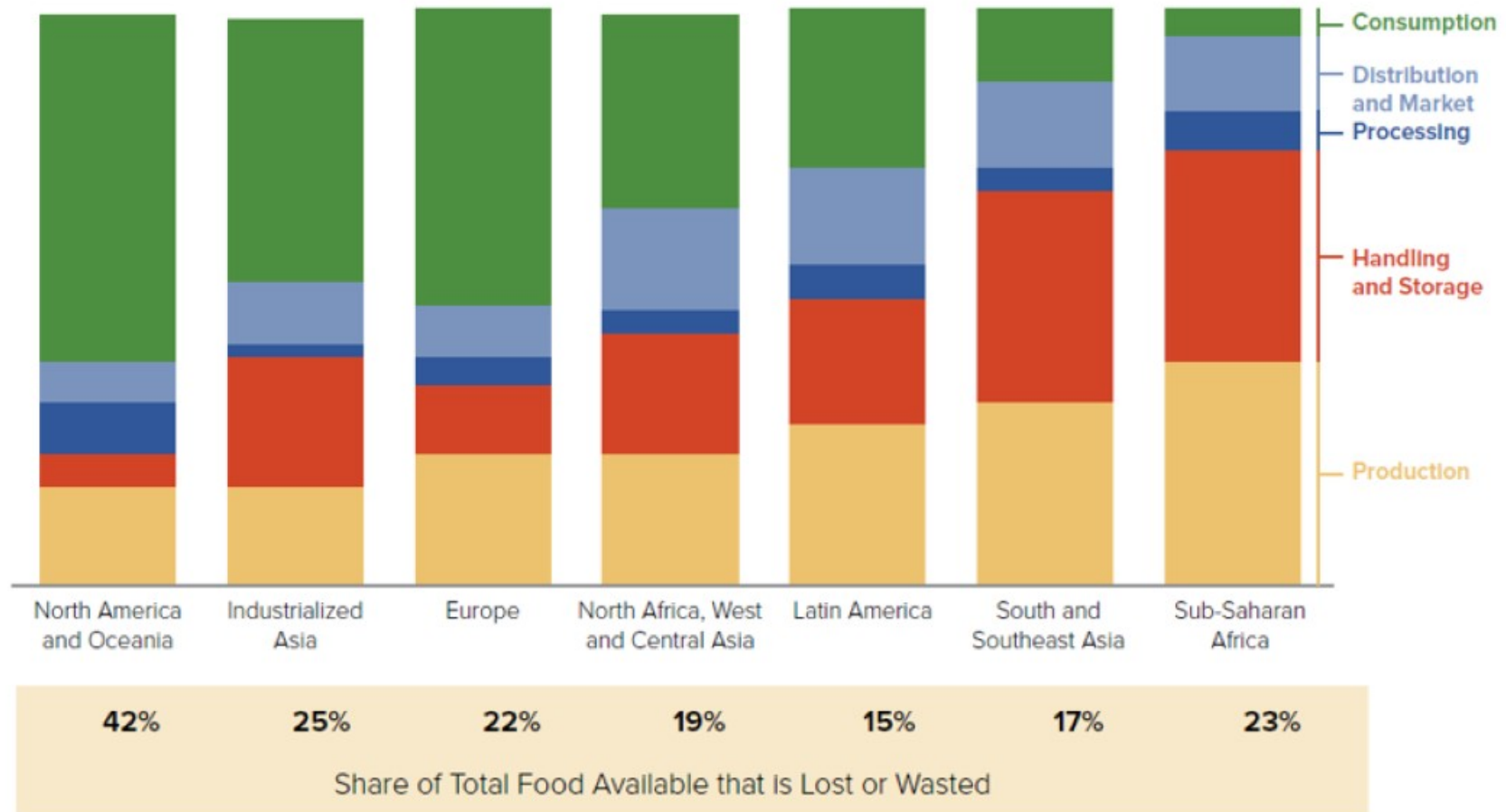
- The burning of tropical forests accounted for more than 5% of all anthropogenic CO<sub>2</sub> emissions.
- Managing waste biomass.
- Reducing food loss.

## Emissions from Tropical Forest Loss.



Source: Data from Climate Watch and Global Forest Watch. Author calculations. Adapted from Seymour and Busch, 2016.<sup>701</sup>

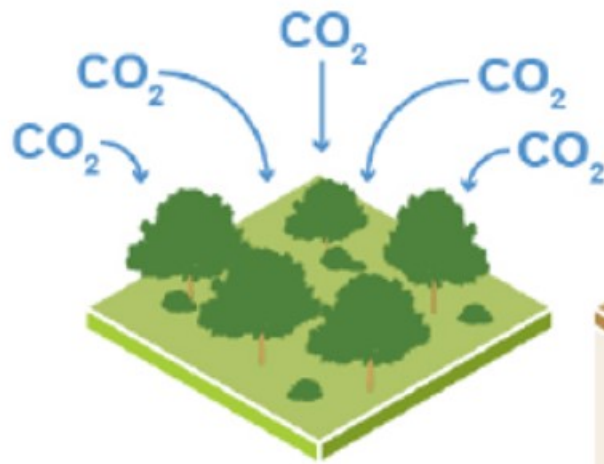
The Majority of Food Waste Occurs in Developed Countries, Whereas Food Loss is the Biggest Problem in Developing Economies.



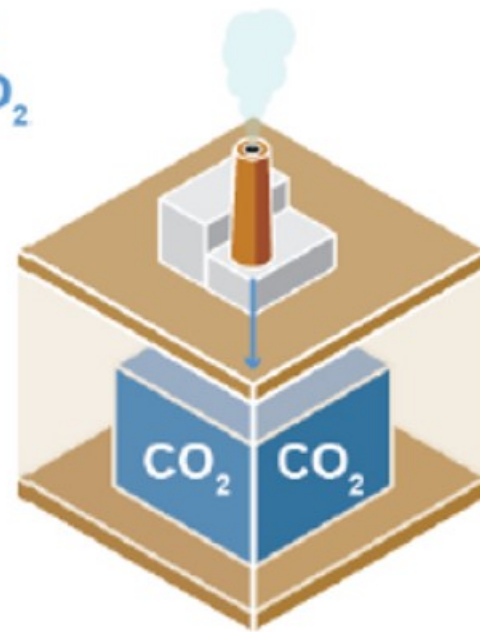
Source: *Champions 12.3, 2017*.<sup>843</sup>

# CO<sub>2</sub> removal

## Bioenergy with Carbon Capture and Storage (BECCS)



Atmospheric CO<sub>2</sub> is absorbed by plants and trees as they grow and then the plant material (biomass) is turned into bioenergy...



...the CO<sub>2</sub> released in the production of bioenergy is captured before it reaches the atmosphere and stored underground

# Debate on action

- The benefits of reducing emissions almost certainly outweigh the damage costs.
  - Damage cost 23~74% of global GDP vs. reduction cost 3~11% (IPCC).
- Issues regarding global emission reduction.
  - At which level or how much should be paid?
  - Who should pay?
- NATO (no action talk only).

# Kyoto protocol

- Adopted in Kyoto, Japan in Dec 1997, effective in 2005.
  - 5% on average reduction compared to '90 in 2008~12.
- Common but differentiated country responsibilities
  - Annex I (42 countries) : OECD and Eastern European countries.
    - To stabilize GHG emissions to 1990 levels by the year 2000.
  - Non-Annex I (154 countries) : Developing countries
    - No obligation to reduce greenhouse gas.
  - Annex II (24 countries) : OECD countries.
    - To give financial and technical supports to developing countries.



# Paris agreement

- Adopted in Paris, France, in Dec. 2015, covering post 2020.
- Commitment to reduce GHG emissions for both developed and developing countries.
  - Long-term objective: Limiting the increase in global average temperature below 2°C or 1.5°C above pre-industrial levels.
- Parties should set voluntary emission reduction goals.
  - Submit Nationally Determined Contributions (NDC) with 5-year time periods.
  - \* principle of progression: Each new goal should be higher than the old one.
- Strengthen transparency.
  - Parties should report emission levels and NDC achievements.
  - Review the 2°C target with international experts.
- Support developing countries' adaptation efforts: capacity building; reinforce disaster response; and decrease vulnerabilities.
  - Finance : 100 bill US\$ per year in 2020~25. Intent to further expand.
  - Transfer of technology

# Talks only, little progress in action.

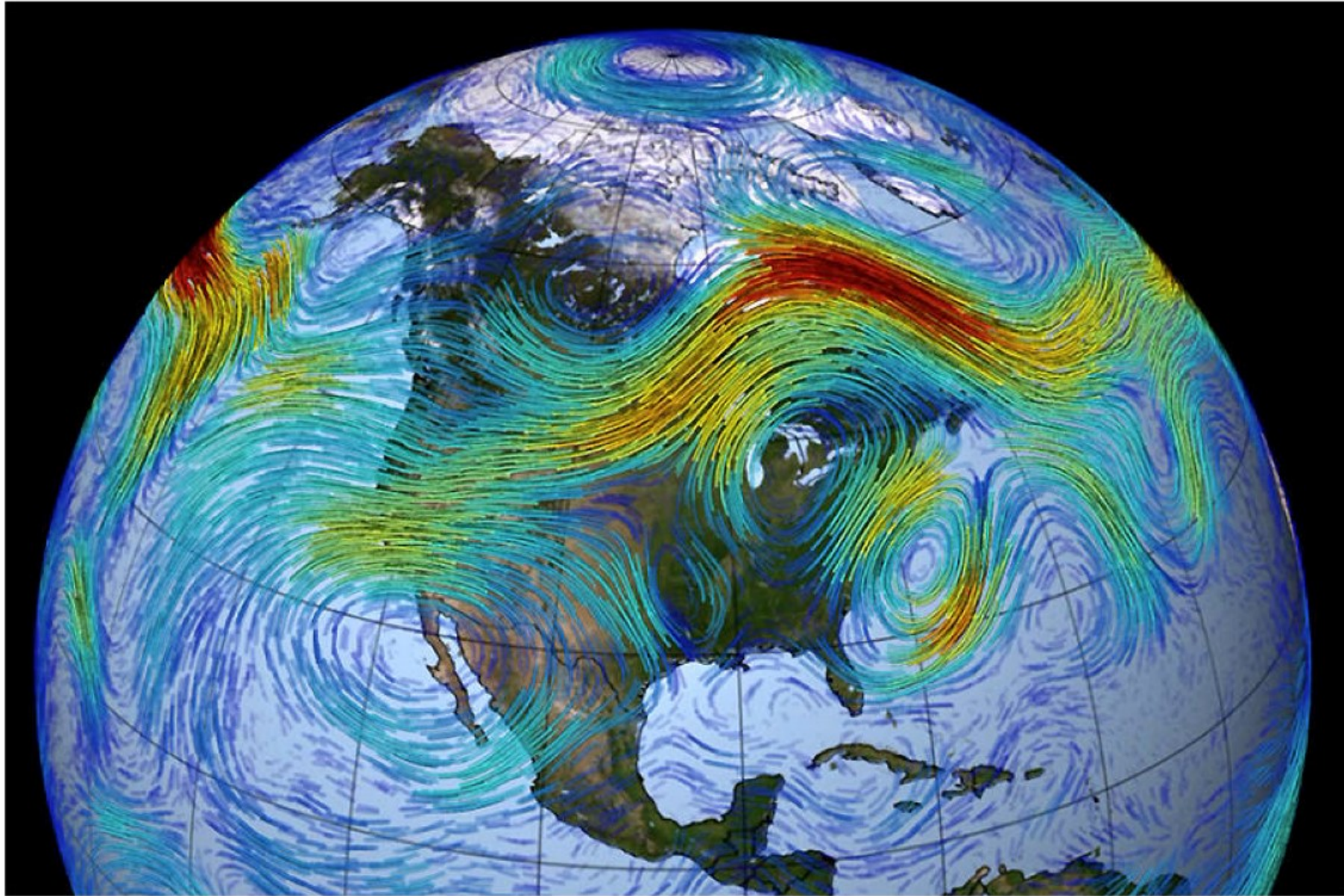
- Kyoto protocol: limited success.
  - US did not ratify. Japan, Russia, New Zealand did not participate in the second commitment period.
  - China, India and other developing countries did not have obligation to reduce GHGs.
  - Emissions of participating countries cover only 22% of the world total for the first commitment period 2008~12.
- Doha amendment: not yet effective as only 121 countries (by Nov 2018) have ratified.
  - $\frac{3}{4}$  of 192 member countries have to ratify to make it effective.
- Paris agreement: became effective in Nov. 2016, but US later withdrew.
  - 55 member countries or emissions more than 55% have to ratify to make it effective.

# Features deterring climate actions

- Free riding incentive.
- Global geopolitics.
- Decision-making fragmented.
- Inter-generational aspect.
- Large uncertainties

# Free riding incentive

- GHGs circulate around the globe.
  - Costs and benefits are globally inter-linked.
- A country can enjoy economic benefits without paying costs.
- An effective system of global governance can fix this issue.



# Prisoner's dilemma

- Over-pollution case
  - (PD1) It is collectively rational to cooperate and restrict overall pollution.
  - (PD2) It is individually rational not to restrict one's own pollution.
- Agents understand that:
  - It would be better for everyone if every agent cooperate.
  - They should all choose to defect.
- Individual agents act rationally in terms of their own interests. However, they collectively undermine their interests.



# Global geopolitics

- Many developing countries argue that developed countries, whose cumulative actions have contributed most to climate change, should bear most of the responsibility for cutting emissions.
  - Controversial as developing countries' emissions have increased rapidly in line with their economic growth.
- Countries are so different in their interests, difficult to agree.

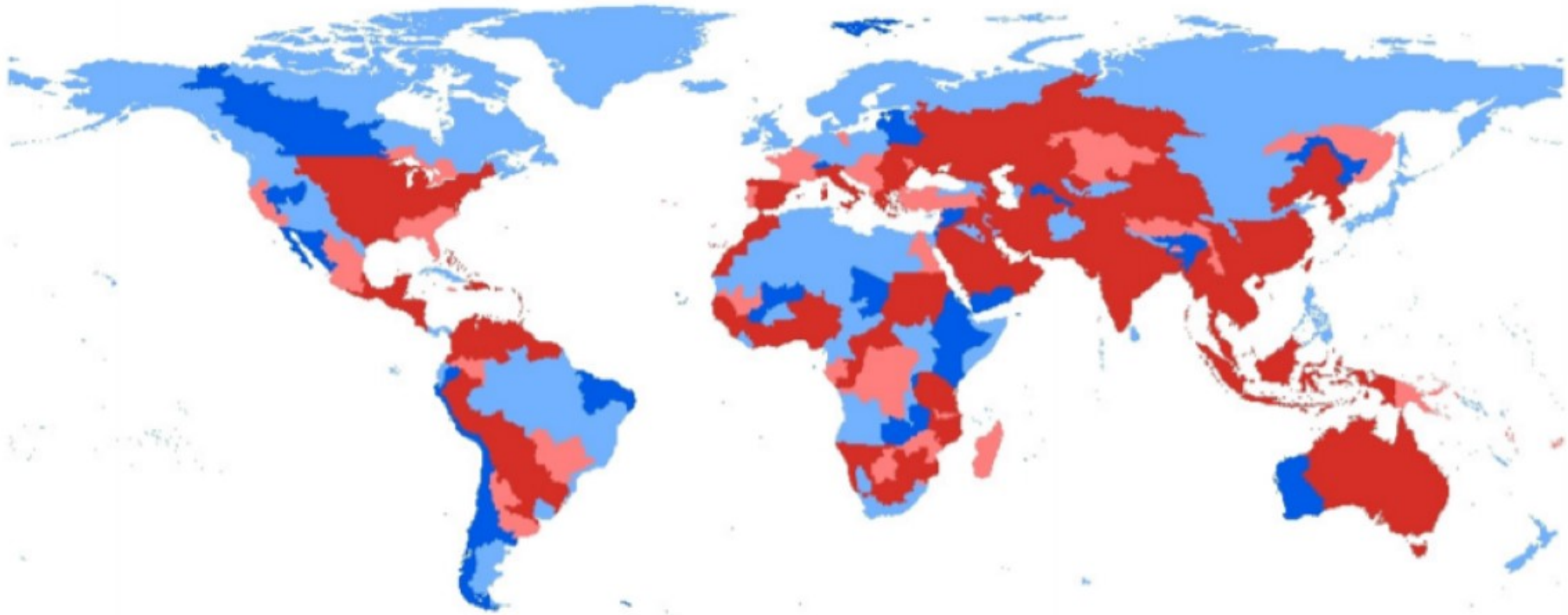
*Table 1*

### Historical and Top 15 Current Emissions of Carbon Dioxide from Fossil Fuel Combustion and Cement Production

<i>Country</i>	<i>Cumulative 1751–2014 (gigatonnes CO<sub>2</sub>)</i>		<i>Emissions 2014 (gigatonnes CO<sub>2</sub>)</i>		<i>Emissions per capita (tonnes CO<sub>2</sub>), 2014</i>
		<i>% of Global</i>		<i>% of Global</i>	
China	174.7	12%	10.3	30%	7.5
United States	375.9	26%	5.3	15%	16.2
India	41.7	3%	2.2	7%	1.7
Russia / USSR	151.3	11%	1.7	5%	11.9
Japan	53.5	4%	1.2	4%	9.6
Germany	86.5	6%	0.7	2%	8.9
Iran	14.8	1%	0.6	2%	8.3
Saudi Arabia	12.0	1%	0.6	2%	19.5
South Korea	14.0	1%	0.6	2%	11.7
Canada	29.5	2%	0.5	2%	15.1
Brazil	12.9	1%	0.5	2%	2.6
South Africa	18.4	1%	0.5	1%	9.1
Mexico	17.5	1%	0.5	1%	3.8
Indonesia	11.0	1%	0.5	1%	1.8
United Kingdom	75.2	5%	0.4	1%	6.5
<b><i>World</i></b>	<b>1,434.0</b>	<b>100%</b>	<b>34.1</b>	<b>100%</b>	<b>4.7</b>

*Source:* Boden, Marland, and Andres (2017).

■ < -15%   ■ -15% to 0%   ■ 0% to 15%   ■ >15%



*Note:* Projected changes in yields for maize in 2050 under climate change as compared with potential 2050 yields if there had been no change in climate after 2005. This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

*Source:* Adapted from OECD / IFPRI (2014), *Modelling Adaptation to Climate Change in Agriculture*, OECD Food, Agriculture and Fisheries Papers, No. 70,

# Decision-making fragmented

- UN system requires unanimous support.
  - Each country has its own sovereignty.
- Countries' policy stances are frequently affected by their political situations.

# How Australia bungled climate policy to create a decade of disappointment

Unlike the UK, Australia has never had climate consensus - and it has been costly, argues Labor frontbencher Mark Butler in an extract from his book, *Climate Wars*

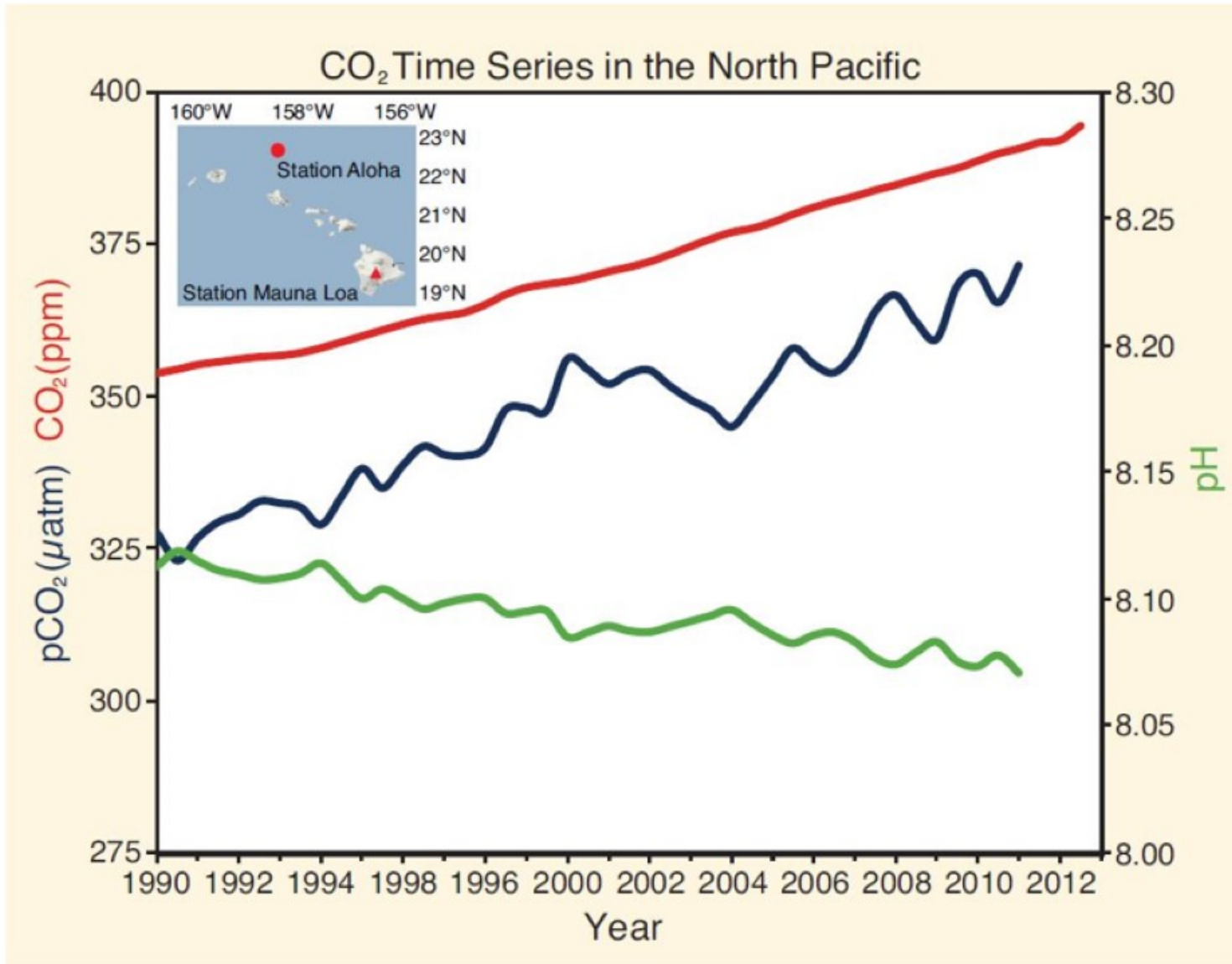


▲ From 'the greatest moral challenge of our time' to a 'great big tax on everything': Australian prime ministers Kevin Rudd, Julia Gillard and Tony Abbott. Composite: Mark Graham; Spencer Platt; Sam Mooy/AAP/Getty Images/AAP

(The Guardian, Jul. 5, 2017)

# Inter-generational aspect

- Climate change impacts are seriously back-loaded.
  - Carbon dioxide lives hundreds of years. Annual flow changes stock very slowly.
  - Oceans warm more slowly than land.
  - The full effects of current emissions will not be realized for some time in the future.
- Little incentive to act now.
  - The bad effects of current emissions fall on future generations, while the benefits accrue to the present.
  - Future generations have not yet been born-- not existing here.
  - Democratic political institutions have short time horizon.





# High uncertainties

- Uncertainties in scientific understanding.
  - Volcanic eruptions, asteroids, variations in the earth's orbit, changes in ocean circulation patterns...
- Uncertainties in technology developments.
- Uncertainties in socio-economic linkages.

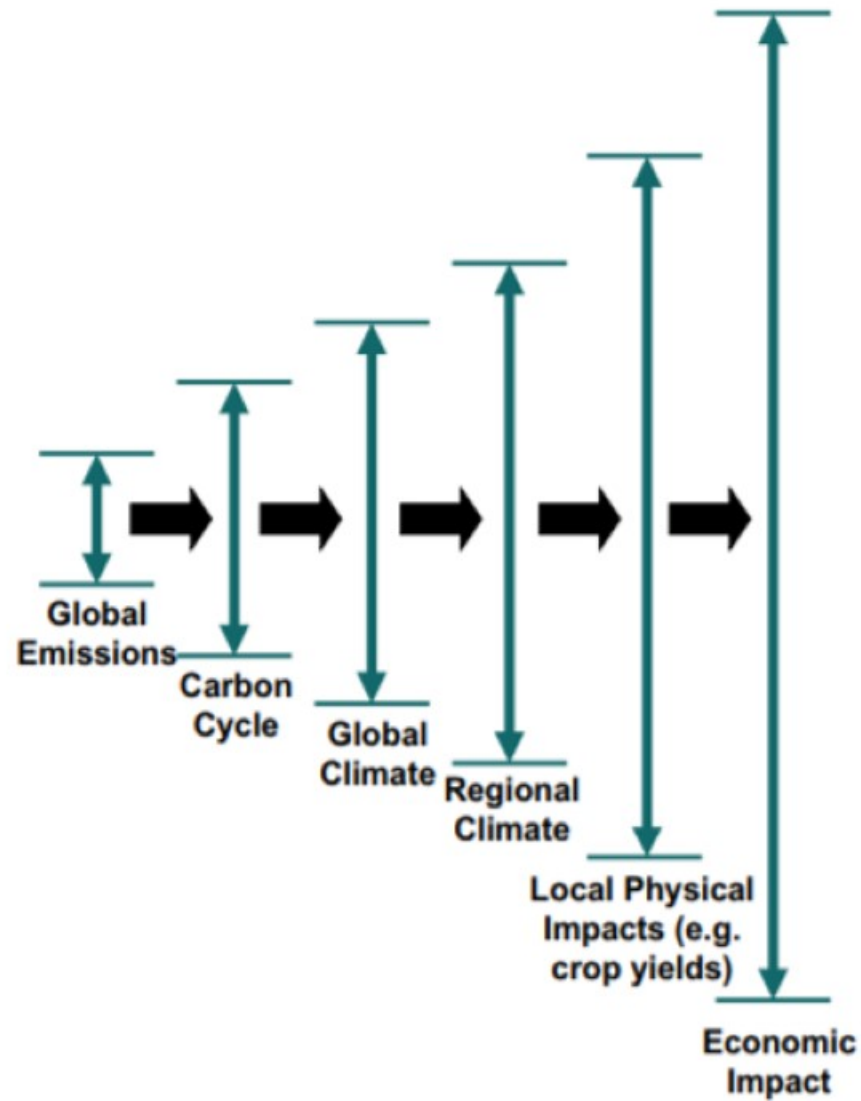


Figure II.1: The 'explosion' of uncertainty from global emissions to local economic impacts (adapted from Jones 2000)

# Technological changes

- Solar PV  
(1977) \$7,600 → (2016) less than \$40
- Off-grid solar generation.
- Electric vehicles.



# Conclusion

- Social collaboration is key.
  - People's support; public sector interventions; private sector cooperation.
- Effective international governance can provide an enabling environment for action.
  - Leading countries' role; enforcing mechanism.
- View in global and long-term perspective.
  - Food and water security; growth opportunity.
  - Consistency in policies.

Thank you!  
Q & A