Agricultural Markets

Lecture 12: Climate and Agriculture

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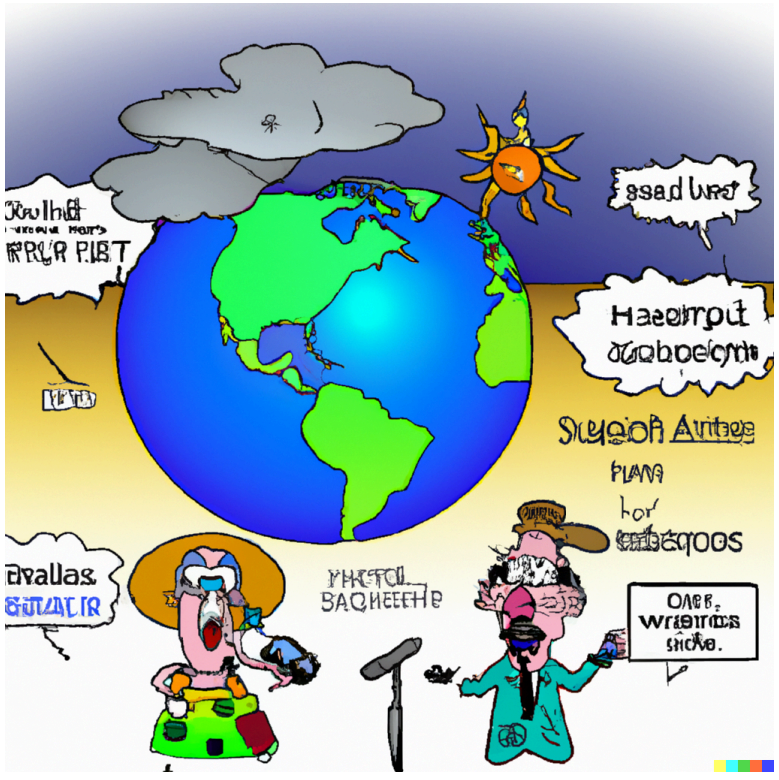
GHG emissions and global warming



- People, through their consumption and production decisions, facilitate Greenhouse Gas (GHG) emissions.
- These flows of GHG emissions accumulate into stocks of GHGs in the atmosphere.
- The stock of GHGs in the atmosphere serves as a 'blanket' that traps heat and results in global warming.

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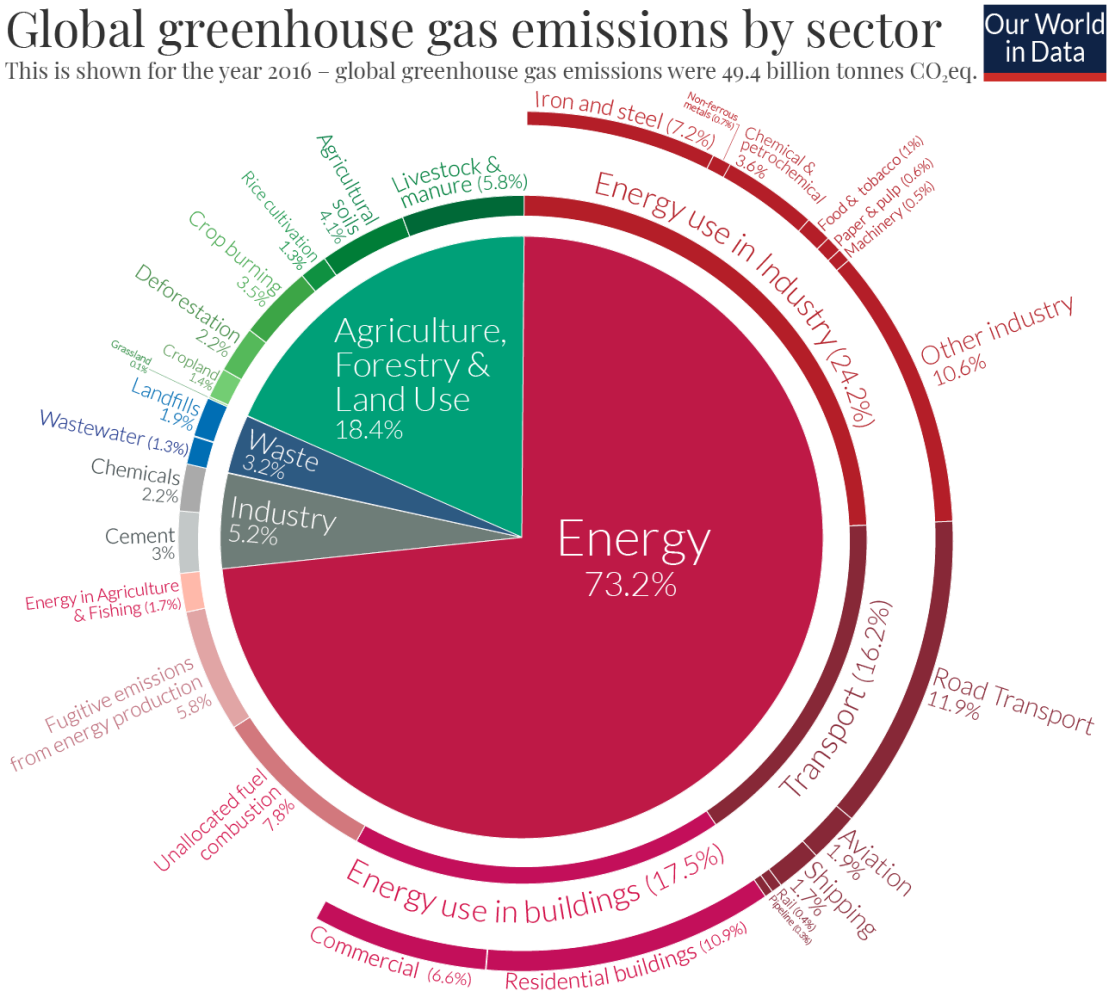
GHG emissions by sector



OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).

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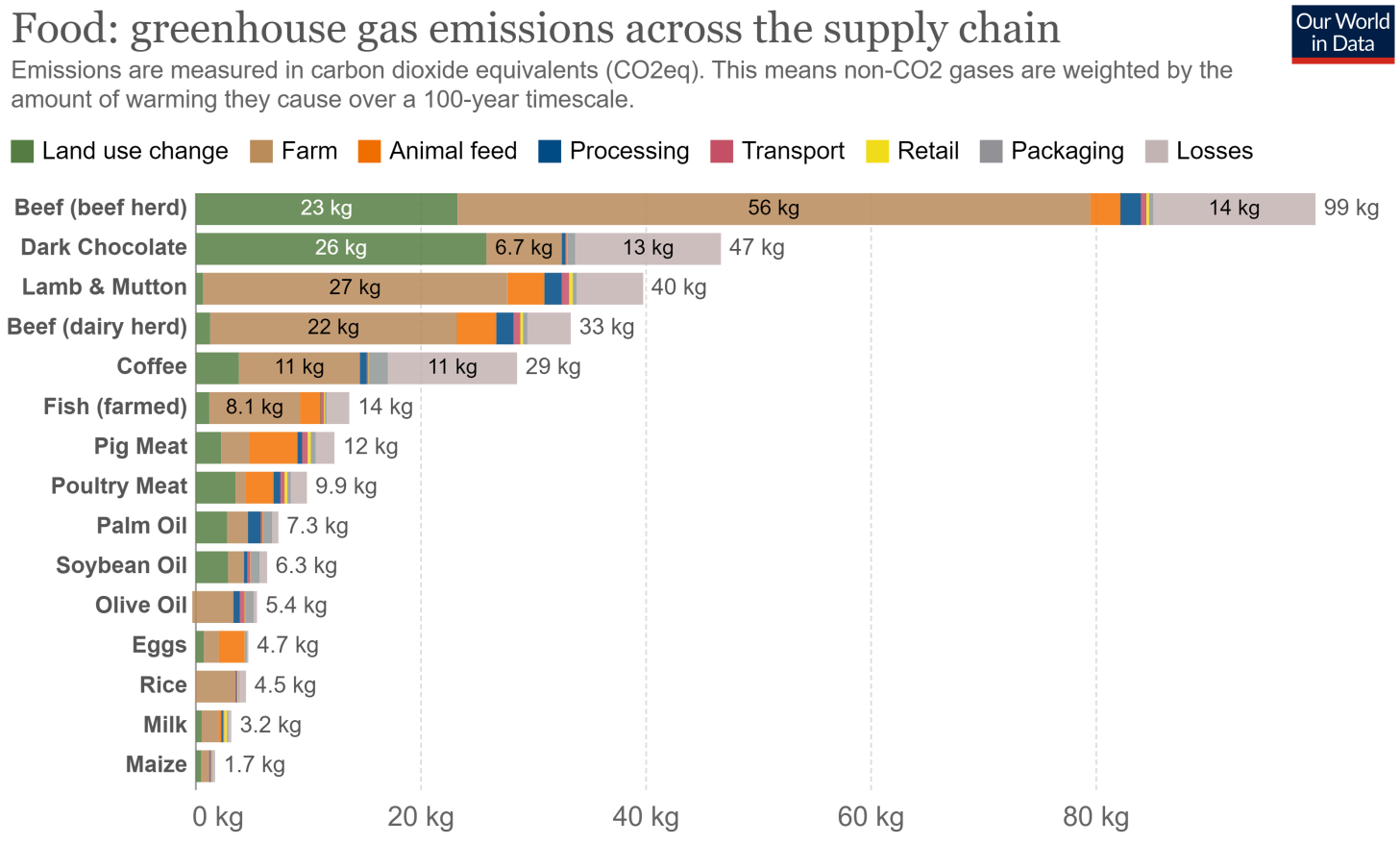
GHG emissions and agriculture



Source: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science.
Note: Greenhouse gases are weighted by their global warming potential value (GWP100). GWP100 measures the relative warming impact of one molecule of a greenhouse gas, relative to carbon dioxide, over 100 years.
OurWorldInData.org/environmental-impacts-of-food • CC BY

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Feedback loop

A feedback loop is where $\mathbf{X}$ causes $\mathbf{Y}$ which either reinforces $\mathbf{X}$ (positive feedback) or stabilizes $\mathbf{X}$ (negative feedback).

Positive feedback effects of global warming

- **Release of methane from the tundra**: as regions of permafrost begin to thaw, potentially large amounts of methane could be released—leading to more warming.
- **Albedo effect**: warming means rain instead of snow as well as retreating polar ice caps and glaciers. This, in turn, means that the surface of the earth is darker, reflecting less solar radiation and absorbing more—leading to more warming.
- **Electricity fuel demand**: warmer weather may increase demand for air conditioning—increasing carbon emissions.

Negative feedback effects of global warming

- **Accelerated CO2 absorption**: as CO2 concentration levels increase, plants and oceans will likely take it up at a higher rate. This mitigates GHG levels and slows warming.
- **Clouds**: a warmer climate could cause more water to be held in the atmosphere leading to an increase in cloudiness and altering the amount of sunlight that reaches the surface of the Earth. Less heat would get absorbed, which could slow the increased warming.
- **Heating fuel demand**: Warmer weather on average may lower demand for heating fuels—reducing carbon emissions.

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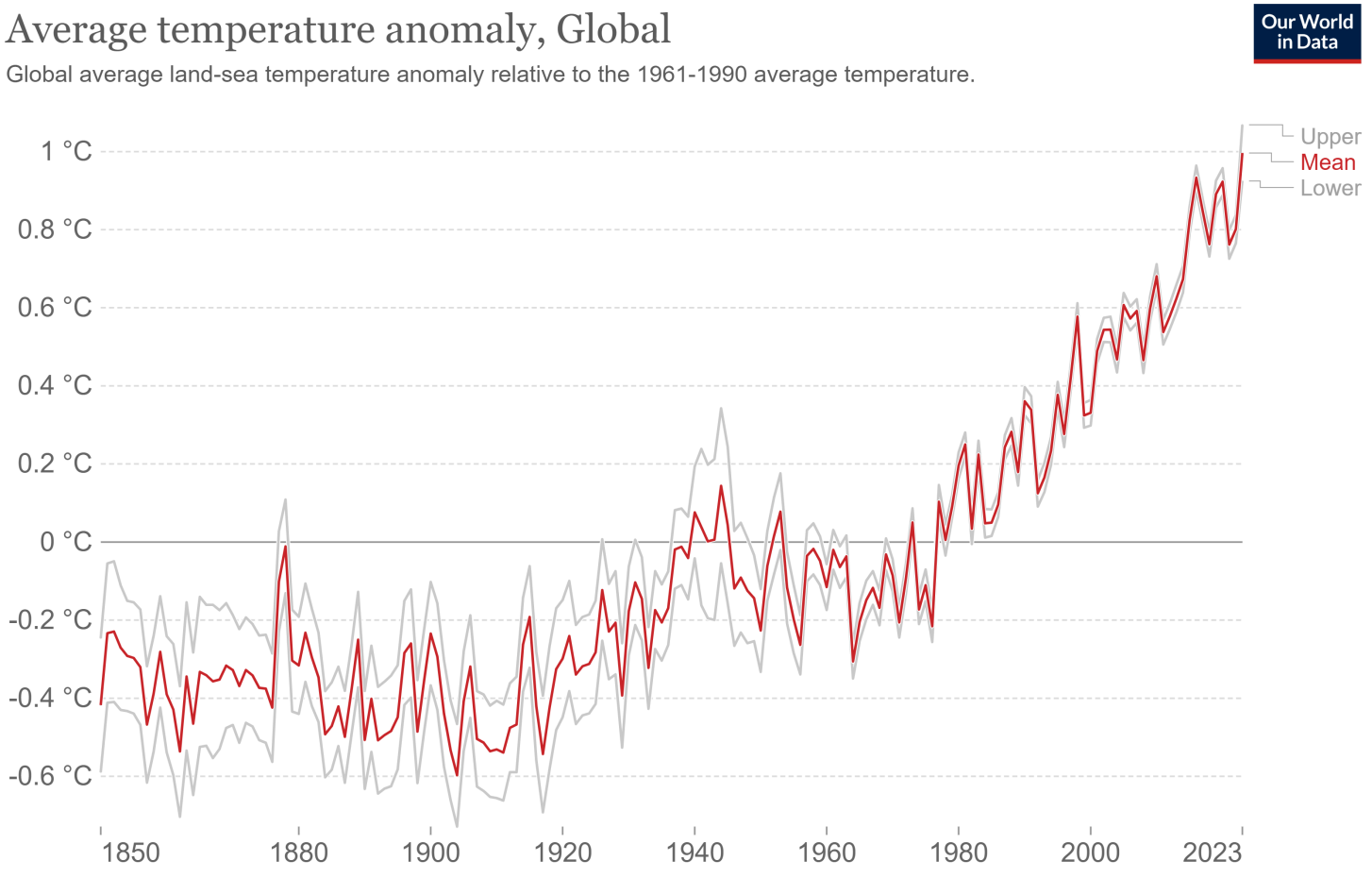
Global warming: Observed



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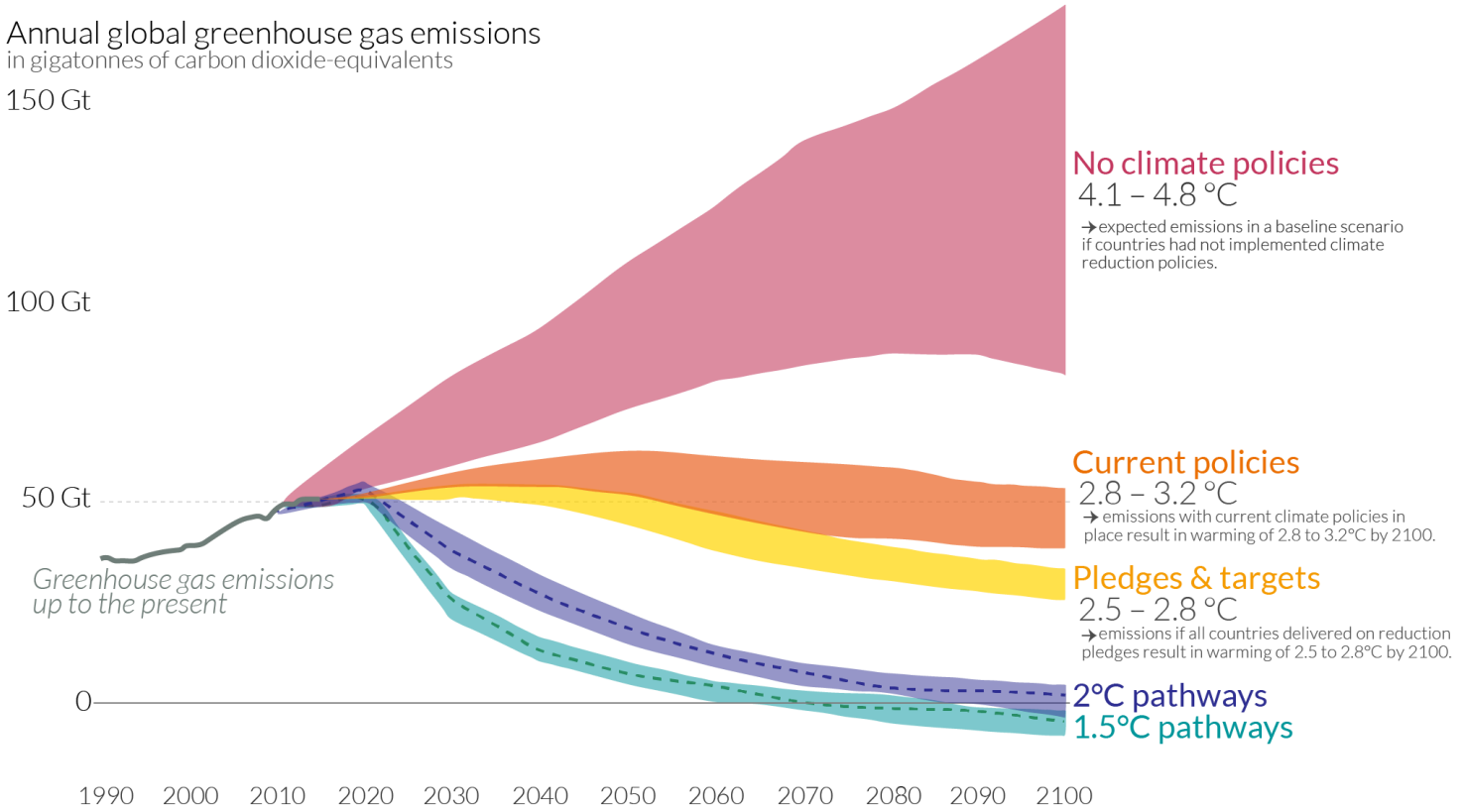
Global warming: Scenarios

Global greenhouse gas emissions and warming scenarios

– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Our World in Data



Data source: Climate Action Tracker (based on national policies and pledges as of December 2019).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

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Climate change

- The process of global warming results in climate change.
- The problem of climate change is inherently a dynamic problem.
  - GHGs accumulate over time - CO2, in particular, has 'long-residence' and is 'well-mixed' in the atmosphere;
  - GHG emission-related impacts are to be felt in the future - both the future climate change and its impacts are uncertain;
  - major polluters may change over time;
  - technology improves over time;
  - we discount future benefits to current costs (trade-off between costs of abatement today vs benefit of less global warming in the future) - the choice of discount rate matters.

Climate Change

- Climate change affects people, species, and plants in a variety of complex ways, most notably via water in some shape or form (storms, floods, droughts, sea-level rise).
- These changes will potentially transform the physical and human geography of the planet, affecting where and how we live our lives.
- Lower income countries to feel most severe effects.

The effect of climate change

- Semi-arid and arid areas in sub-Saharan Africa and coastal areas in Asia to suffer from increased likelihood of drought, and growing heat stress, as well as decrease in water availability, including in ground-water resources, leading to moisture-related plant stress.
- Other areas to feel more mixed effects, including improved agricultural productivity in higher latitude areas, but overall the most likely outcomes are increased variability in weather patterns, including deeper and more prolonged drought, higher temperatures and reduced productivity in rain-fed tropical and sub-tropical agriculture, reductions in access to fresh water, and expanding populations of pests and diseases.

Estimating the effect of climate change

- **Model-based**—obtain parameters (lab/field experiments), and simulate economic outcomes under different climate change scenarios
  - Advantage: out-of-sample simulations
  - Disadvantage: heavily driven by parameters used
- **Data-driven**—estimate historical relationship between weather and economic outcome, and project the relationship under different climate change scenarios
  - Advantage: evidence-based
  - Disadvantage: lack of external validity

Estimating the effect of climate change

- **Cross-sectional** data analysis—comparing across locations in a given time period:
  - Useful for estimating effect of climate;
  - Source of variation is differences in climate across locations;
  - Should capture adaptation, but may result in biased estimates.
- **Time series** data analysis—comparing over time in a given location:
  - Useful for estimating effect of weather;
  - Source of variation is differences in weather over time;
  - Relatively unbiased, but may not capture adaptation.

Adaptation to climate change

- As climate change affects agriculture productivity, people respond to it by adjusting their farming techniques and their livelihood strategies. In the short run:
  - on farm they change crop mixes, use water conservation measures, and adopt risk-management techniques to lessen the consequences of more frequent droughts.
  - off farm they engage in activities that are less prone to weather shocks, which may include migration to earn incomes.

Adaptation to climate change

- Over the longer run, steps can be taken to lessen vulnerability to rainfall shortages and increase productivity over time:
  - governments may invest in technologies and production techniques that reduce the impact of climate change;
  - agricultural research systems may respond by producing shorter-season seed varieties that are more tolerant of drought, rice varieties that are more tolerant of salinity;
  - farmers may adopt conservation techniques that minimize disruption of the soils and increase the use of ground-cover to reduce erosion and increase soil organic matter.

Mitigation of climate change

- GHGs are a global externality, which makes it hard to tackle.
- For example, we obtain benefits from the demand for fossil fuels by powering factories, heating or cooling houses, driving cars, etc.
- In addition to the private cost of production, however, the use of fossil fuels imposes an external cost to society by emitting GHGs.

Mitigation of climate change

- GHGs as local externality: air pollution
  - Pollution arises and affects people within the same jurisdiction;
  - Government can implement policies that affect all producers equally (to correct externality), reducing free-riding incentives.
- GHGs as global externality: climate change
  - Emissions and damages arise and are felt across jurisdictions;
  - Impossible for a single government to tackle the problem: need international agreement or cooperation.

Mitigation of climate change

- Actions taken to reduce climate change are a global public good: one cannot exclude some countries from benefiting from actions of the others.
- Free-rider effects inhibit participation in agreements on preventing or mitigating climate change.
- Countries have an incentive to defect from any agreement (not cut emissions) and benefit from the efforts of others nations.

Mitigation of climate change

- The challenge is to make cooperation self-reinforcing, in a way that there is no incentive to unilaterally defect from the agreement.
- Certain strategies can make participation more likely by increasing the net benefits from participation:
  - Countries may simultaneously negotiate a climate change agreement and another economic agreement on a linked issue, e.g. trade;
  - Countries may agree on transfers from gainers to losers or a redistribution of net benefits.

Mitigation of climate change

- Agriculture can play an important role in slowing climate change.
  - Conservation agriculture can help sequester carbon in soils and contribute to reductions in greenhouse gas emissions.
  - Intensified agricultural production in currently cropped areas increases overall food availability and lowers rates of land clearing for new productive areas.
  - Perennial crop producers can plant trees and manage their existing woodlands to contribute to carbon retention.
- The challenge is to create mechanisms whereby farmers can be compensated for improving the global environment.

Readings

Norton, Alwang & Masters, Chapter 9