IPCC Special Report on Climate Change and Land: Land-Climate interactions

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Key messages

- Land is at risk due to climate change, but also contributes to climate change, thus sustainable land management is critical for climate mitigation and adaptation.
  - Climate change poses risks to biodiversity and food production
  - Agriculture, forestry and land use contribute around a third of greenhouse gas emissions
  - Mitigation is limited by the need to feed people and by available land
Climate impacts on land
Model projections of climate change from 1986-2005 to 2081-2100

Changes are not equal everywhere

Graphs show annual average change, not extremes.

IPCC 5th Assessment Report, Synthesis Report fig 2.2.

Scenario: RCP2.6 = 0.9 to 2.3°C  RCP8.5 = 3.2 to 5.4°C

Temperature

Precipitation

Sea level
Model projections of climate change from 1986-2005 to 2081-2100

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- Temperature
- Precipitation
- Sea level

- extreme events
- CO$_2$ fertilisation
- distribution of pests and diseases

IPCC 5$^{th}$ Assessment Report, Synthesis Report fig 2.2.
Biome shifts and productivity changes during the 20th Century

- Anthropogenic warming has resulted in shifts of climate zones, primarily as an increase in dry climates and decrease of polar climates (*high confidence*).

- Ongoing warming is projected to result in new, hot climates in tropical regions and to shift climate zones poleward in the mid- to high latitudes and upward in regions of higher elevation (*high confidence*)
Risks to humans and ecosystems from climate change

- Temperature change relative to pre-industrial °C

- Livelihoods
- Value of land
- Human health
- Ecosystem health
- Infrastructure

- Dryland water scarcity
- Soil Erosion
- Vegetation loss
- Wildfire damage
- Permafrost degradation
- Tropical crop yield decline
- Food supply instabilities

- Over 100M people additionally exposed
- Over 50% increase in area burned in Med

- Increase in fire weather season

Legend: Level of impact/risk
- Very high
- High
- Moderate
- Undetectable

- Infrquent price spikes affect individual countries
- Periodic food shocks across regions
- Sustained food supply disruptions globally

IPCC SRCCL SPM fig 2
Risks to humans and ecosystems from climate change

Temperature change relative to pre-industrial °C

- Dryland water scarcity
- Soil erosion
- Vegetation loss
- Wildfire damage
- Permafrost degradation
- Tropical crop yield decline
- Food supply instabilities

1.5°C

2006-2015

- Over 100M people additionally exposed
- Over 50% increase in area burned in Med

- Increase in fire weather season

Wildfire damage

Food supply insecurities

Legend: Level of impact/risk

- Very high
- High
- Moderate
- Undetectable

Infrequent price spikes affect individual countries

Sustained food supply disruptions globally

Periodic food shocks across regions
Natural disturbances and extremes, fires, floods, pests and diseases;

- Increase in frequency and intensity in some places, reduction in others
- Fires burning in tropical forests where unexpected

burned for 6 days in May 2019
Land impacts on climate
Extent of land use and management, 2015

1% infrastructure
12% cropland
37% pasture
22% managed forests
16% minimal human use
12% barren, etc.
Changing trends in intensity of agriculture from 1961 to 2017 has supported increased production, but also caused greenhouse gas emissions.

- Inorganic fertiliser use: 800% increase – emits nitrous oxide
- Increase in cereal yields around 200%
- Increase in irrigation water volume
- Total number of ruminant livestock
Change in anthropogenic greenhouse gas emissions 1961-2016

Agriculture, Forestry and Other Land Use (AFOLU) activities accounted for 23% of total net anthropogenic emissions of GHG during 2007-2016

1. 13% of carbon dioxide CO$_2$ from deforestation, afforestation, and other land cover change
2. 44% of methane CH$_4$ from agriculture
3. 82% of nitrous oxide N$_2$O from agriculture

Including pre- and post-production activities in the global food: 21-37% of total net anthropogenic GHG emissions
The natural response of land to human-induced environmental change caused a net sink of around 11.2 GtCO₂ yr⁻¹ during 2007-2016 (equivalent to 29% of total CO₂ emissions) (medium confidence).

The persistence of the sink is uncertain due to climate change (high confidence).
Carbon dioxide net emissions and removals from land use, land use change and forestry

National greenhouse gas inventories (yellow) show much smaller net emissions than global models (red and blue). They assume some of the sink due to environmental change to be anthropogenic if it occurs on “managed lands.”

Needs to be reconciled for the Paris Agreement Global Stocktake 2023
Average agricultural methane (CH$_4$) emissions estimates from 1990 to 2016

- Waste burning
- Manure
- Rice
- Ruminant animals

IPCC SRCCL, fig 2.9
Average agricultural nitrous oxide (N$_2$O) emissions estimates from 1990 to 2016

IPCC SRCCL, fig 2.11
Responding: mitigation and adaptation
How do we get to 1.5 degrees?

Billion tonnes CO₂ per year (GtCO₂/yr)

- Fossil fuel and industry
- Agriculture, Forestry
- Bioenergy with Carbon Capture and Storage

Net emissions = balance

emissions

removals

2020  2060  2100
Land use Change in 1.5 and 2 °C consistent pathways

There are multiple different pathways that can limit warming.

Less bioenergy would require more afforestation to meet targets:

- Bioenergy area change 0-750 Mha (roughly the size of India)
- Forest area -200 to 7200 Mha change
Mitigation in the land sector

- Reduced emissions from agriculture
- Reduced emissions from forests and other ecosystems
- Carbon dioxide removal
- Demand management

IPCC SRCCL fig 2.24, from Roe et al Nature climate change 2019
Improved synthetic fertilizer production

Reduce emissions from Forests and other Ecosystems
- Reduce deforestation: 0.05–0.36
- Reduce forest degradation: 1–2.18
- Reduce conversion, draining, burning of peatlands: 0.45–1.22
- Reduce conversion of coastal wetlands (mangroves, seagrass and marshes): 0.11–2.25
- Reduce conversion of savannas and natural grasslands: 0.03–0.12

Carbon Dioxide Removal
- Afforestation/Reforestation (AVR): 0.50–10.12
- Forest management: 0.44–2.10
- Agroforestry: 0.11–5.68
- Peatland restoration: 0.15–0.81
- Coastal wetland restoration: 0.20–0.84
- Soil carbon sequestration in croplands: 0.25–0.78
- Soil carbon sequestration in grazing lands: 0.13–2.56
- Biochar application: 0.03–6.60
- BECCS deployment: 0.40–11.30

DEMAND MANAGEMENT
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