ERASMUS-EDU-2023-CBHE
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(01/01/2024 – 31/12/2026)

LESLIE
LAND MANAGEMENT
ENVIRONMENT &
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Climate Change of Sustainable Land Management in Central Asia

1- Climate vs Weather and Why Climate Change Matters

Greenhouse Effect and Key Greenhouse Gases

CC-W01-V03



The natural greenhouse effect

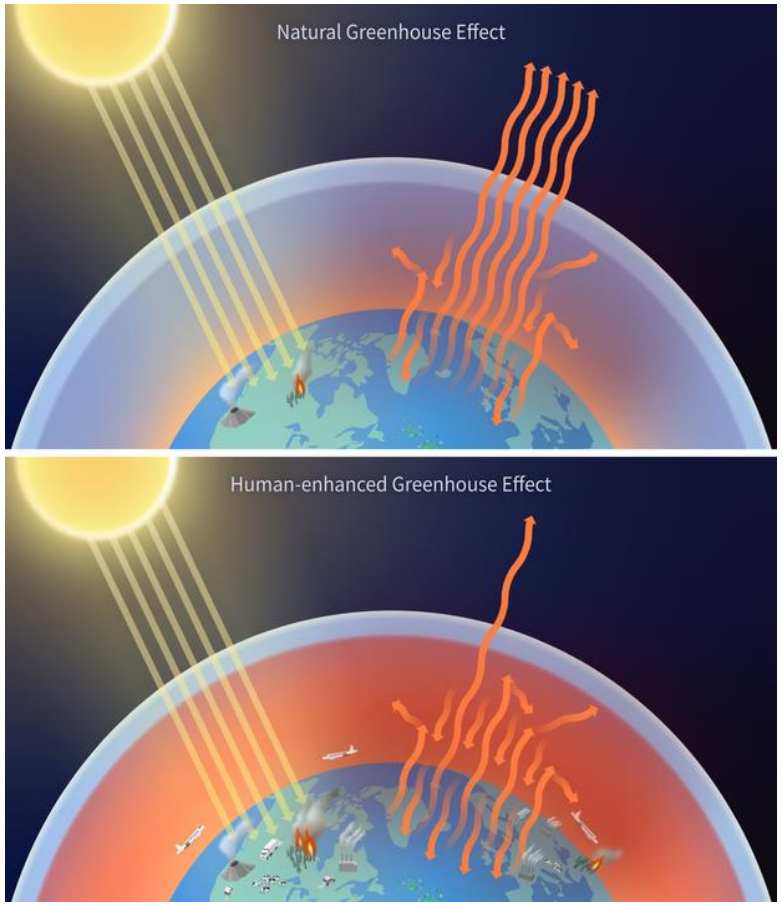


Natural Greenhouse effect NASA Science, 2010



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Learning goals



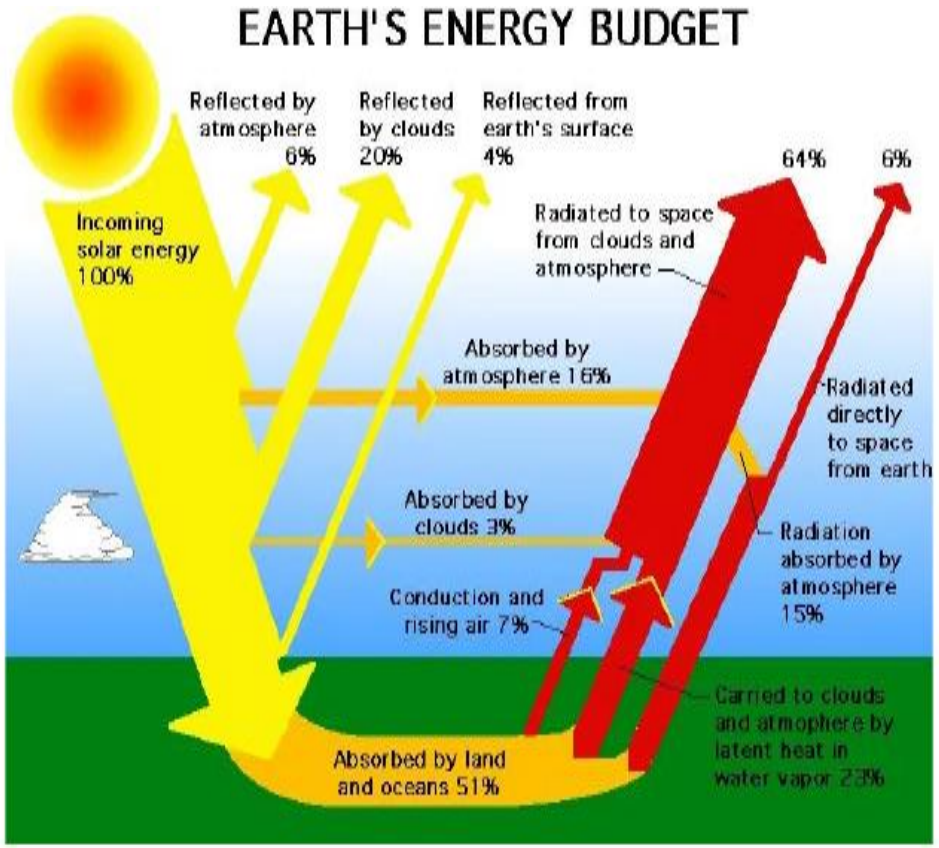
Greenhouse effect diagram. Credit: NOAA Climate Program Office, Graphic by Anna Eshelman

- Earth's average temperature without greenhouse gases, would be about -18 Celsius degrees.
- With the natural greenhouse effect, the global average is close to +15 Celsius degrees.
- Greenhouse gases allow much incoming shortwave radiation to pass.
- Greenhouse gases, absorb outgoing longwave radiation

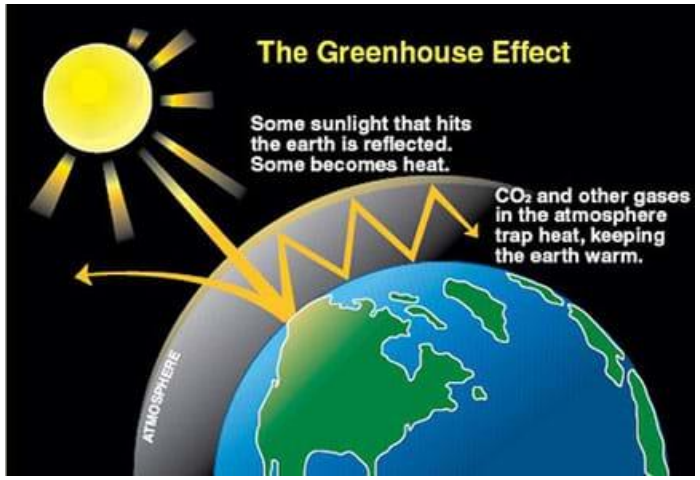


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Earth's energy balance



- Climate depends on the balance between incoming solar energy and outgoing infrared heat.
- Some incoming radiation is reflected by clouds, the atmosphere, and bright surfaces.
- The rest is absorbed by land, ocean, and atmosphere.
- If more energy is retained than lost, the system warms.



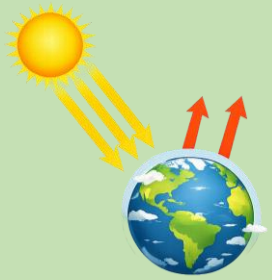


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Radiative forcing: a working concept

- Radiative forcing measures how strongly a factor changes Earth's energy balance.
- Positive forcing pushes the system toward warming.
- Negative forcing pushes the system toward cooling.
- Greenhouse gases are positive forcing agents because they trap outgoing heat.

Positive forcing



- Extra greenhouse gases
- More heat retained
- Trends toward warming

Negative forcing



- Reflective aerosols
- More sunlight bounced away
- Trends toward cooling

Source: Author's Creation



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Major greenhouse gases at a glance

Gas	Major Source	Atmospheric Lifetime	Land-Management Connection
Carbon Dioxide (CO_2)	Fossil fuels, Deforestation	100 - 1000+ years	Soil carbon storage and forest conservation
Methane (CH_4)	Agriculture, Animal farms, Wetlands, Gas leaks	~12 years	Livestock management and rice cultivation
Nitrous Oxide (N_2O)	Fertilizers, Industrial use	~110 years	Fertilizer efficiency and soil management
Fluorinated Gases	Refrigeration, Electronics	Weeks to Millennia	Limited land link but stron climate forcing



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CO_2, CH_4, and N_2O in land systems

CO_2	CH_4	N_2O
Long-lived	Short-lived	Long-lived
Deforestation, energy, soil carbon	Livestock, wetlands, manure	Fertilizers, soil management
Key issue: Accumulation	Key issue: Strong heat trap	Key issue: Land management

Source: Author's Creation

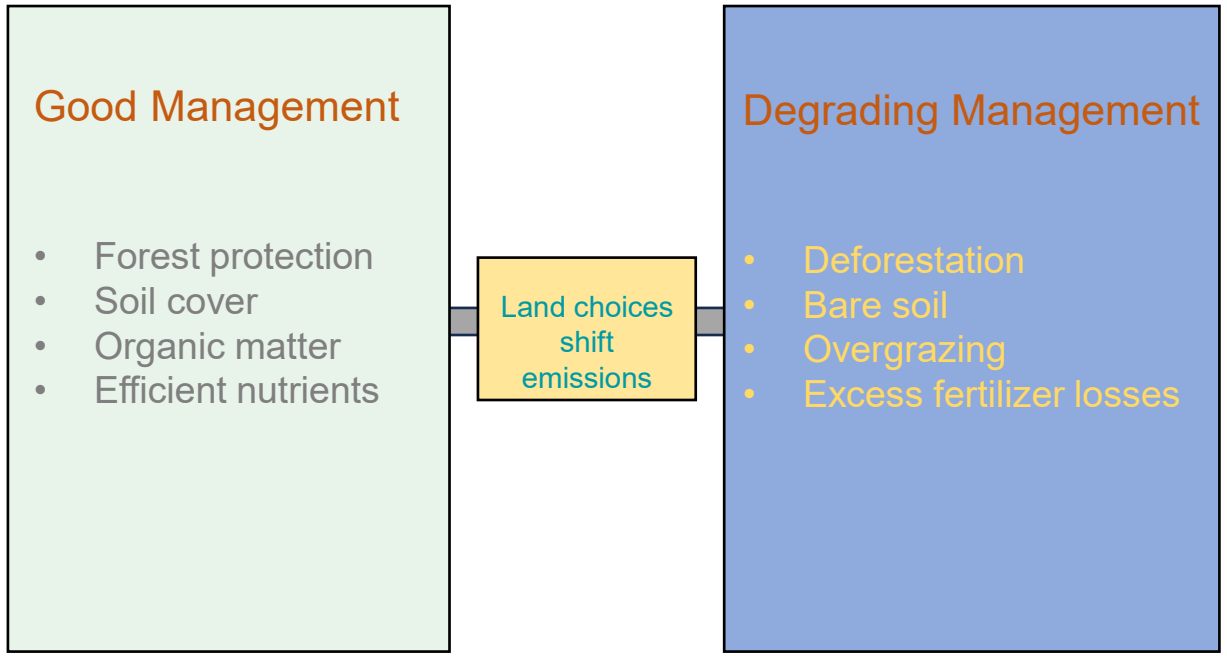


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The land-management connection

- Land can be both a source of greenhouse gases and a sink for carbon.
- Deforestation, soil disturbance, and poor grazing reduce carbon storage and increase emissions.
- Better soil management can improve water retention and carbon storage together.
- Mitigation and land restoration often reinforce one another.

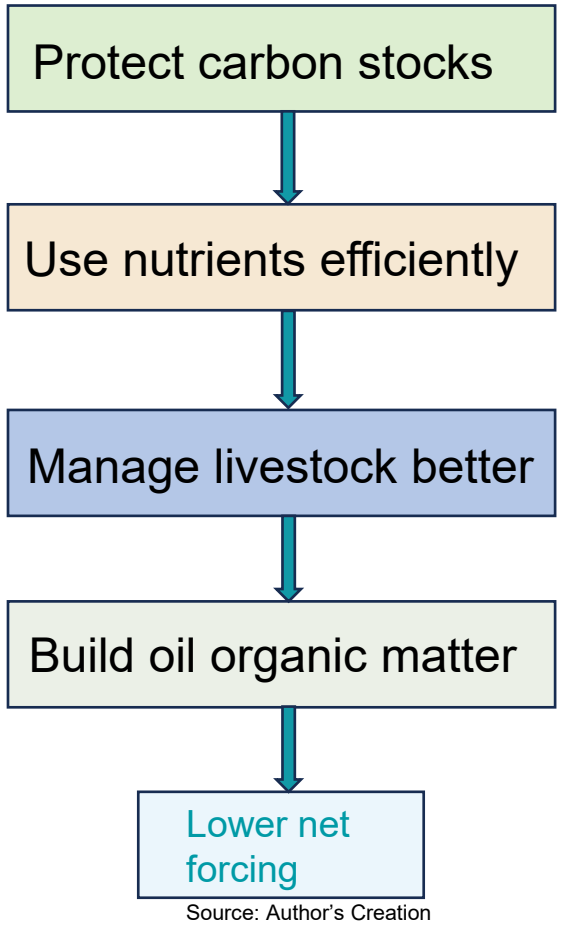




Source: Author's Creation

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Practical mitigation levers for land systems



Source: Author's Creation

- Protect forests and existing carbon stocks.
- Improve fertilizer efficiency and nutrient timing.
- Use grazing, manure, and livestock management to lower methane pressure.
- Build soil organic matter through conservation-oriented land management.



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Final

- The natural greenhouse effect is necessary, but human activity has enhanced it.
- Radiative forcing explains how extra greenhouse gases shift the energy balance.
- Major gases differ by source, lifetime, and land-management connection.
- The next step is to apply these ideas to a vulnerable region: Central Asia.

Quick Exercise

Concept-Map worksheet: “From greenhouse gases to land impacts in Kazakhstan and Uzbekistan”



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