Special Report on Climate Change and Land

www.ipcc.ch/report/SRCCL

Agricultural landscape between Ankara and Hattusha, Anatolia, Turkey (40°00' N – 33°35' E)

SBSTA-IPCC special event on unpacking the new scientific knowledge and key findings in the IPCC Special Report on Climate Change and Land

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INTERGOVERNMENTAL PANEL ON climate change

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SRCCL REPORT BY THE NUMBERS

107 Authors → 52 Countries → 53% Authors from Developing Countries

→ > 7,000 Scientific Publications Assessed → 28,275 Review Comments → 596 Expert and Government Reviewers

INTERGOVERNMENTAL PANEL ON climate change

Land is where we live

Land is under growing human pressure

Land is a part of the solution

Land can’t do it all

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IPCC governments and observers made six proposals for land-related Special Reports at the start of the Sixth Assessment Cycle

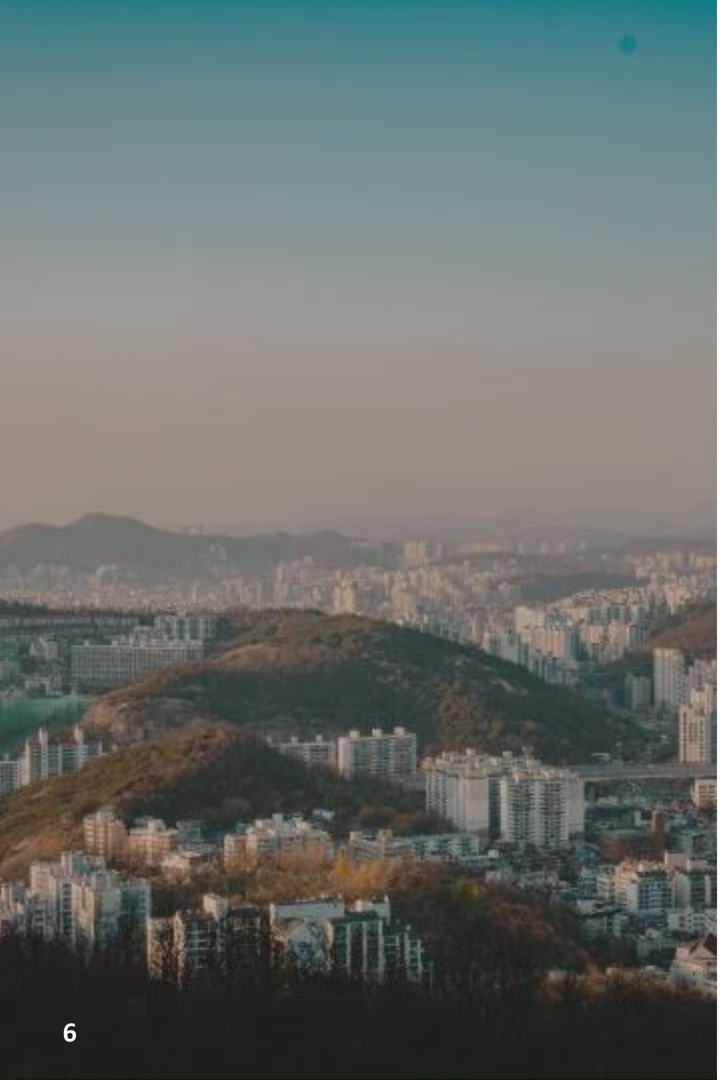
- Climate change and desertification (Algeria)
- Desertification with regional aspects (Saudi Arabia)
- Land degradation - an assessment of the interlinkages and integrated strategies for mitigation and adaptation (UNCCD)
- Agriculture, forestry and other land use (EU)
- Climate change, food and agriculture (Ireland)
- Food security and climate change (CAN International)

In April 2016, the Panel decided on a single land-related report

"Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems"

Or, short titled,

"IPCC Special Report on Climate Change and Land (SRCCL)"



Recognising parallel efforts by other intergovernmental bodies, IPCC organised three web-based consultations ***prior*** to the scoping meeting

- IPBES (Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services)
- FAO (UN Food and Agriculture Organization)
- UNCCD (UN Convention to Combat Desertification)

Key message:

- Maintain focus on land-climate nexus, don’t duplicate

1: Framing and Context

2: Land-Climate Interactions

3: Desertification

4: Land Degradation

5: Food Security

6: Interlinkages between desertification, land degradation, food security and GHG fluxes: Synergies, trade-offs and Integrated Response Options

7: Risk management and decision making in relation to sustainable development

Report Structure

Section A: People, land and climate in a warming world

Section B: Adaptation and mitigation response options

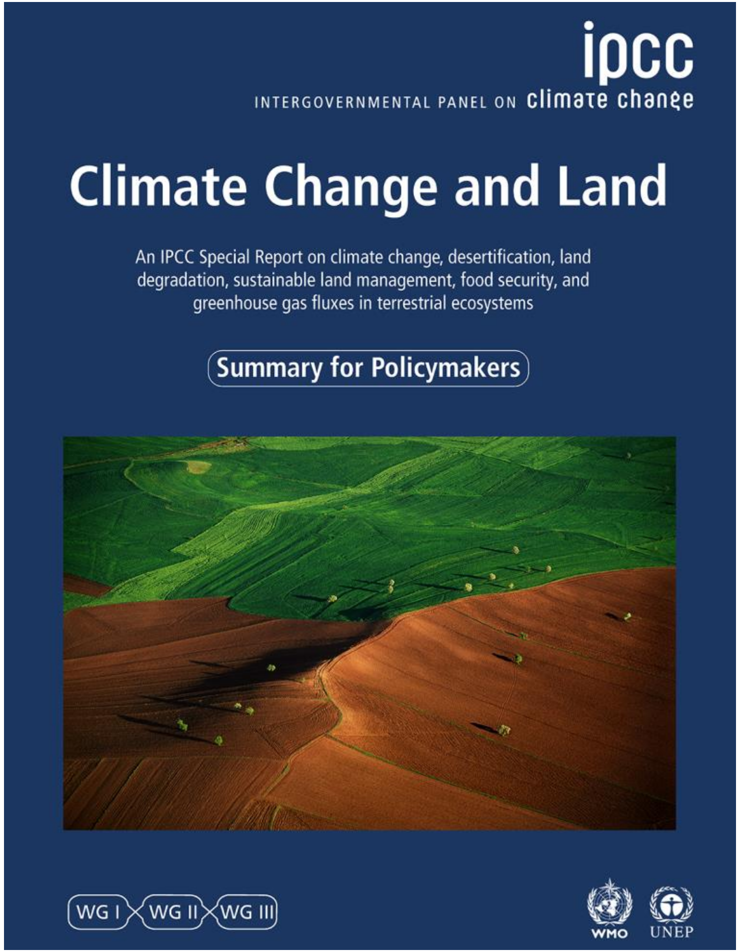
Section C: Enabling response options

Section D: Action in the Near Term

SPM Structure

CLIMATE CHANGE AND LAND

An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.



REPORT COVER IMAGE:
Agricultural landscape between Ankara and Hattusha, Anatolia, Turkey (40°00' N – 33°35' E)
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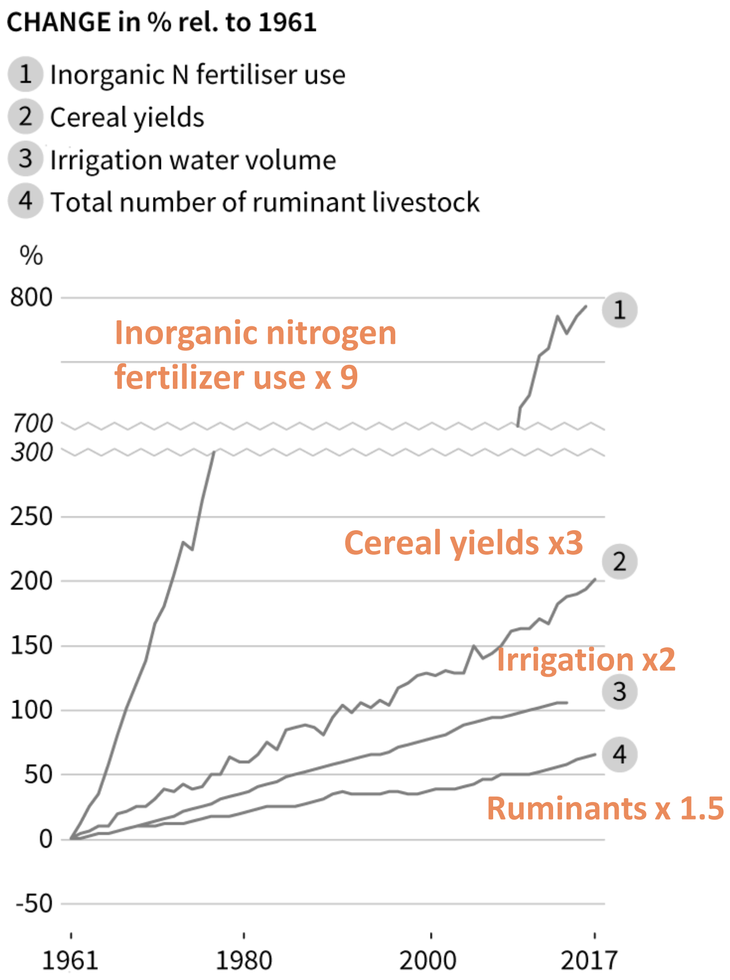
“Land is a critical resource –
we rely on it for food, water, health and wellbeing – but it is already under growing human pressure. Climate change is adding to these pressures

Land is under growing human pressure with unprecedented rates of land and freshwater use

- Human activities directly affect more than 70% of the global, ice-free and surface
- People currently use ¼ to 1/3 of land’s potential net primary production for food, feed, timber and energy
- About 1/4 of the global ice-free land area is subject to human-induced degradation
- Since 1961, population growth and changes in per capita consumption of food, feed, fiber, timber and energy have caused unprecedented rates of land and freshwater use



- Human activities directly affect more than 70% of the global, ice-free and surface
- **People currently use ¼ to 1/3 of land's potential net primary production for food, fed, timber and energy**
- **About 1/4 of the global ice-free land area is subject to human-induced degradation**
- Since 1961, population growth and changes in per capita consumption of food, feed, fiber, timber and energy have caused unprecedented rates of land and freshwater use

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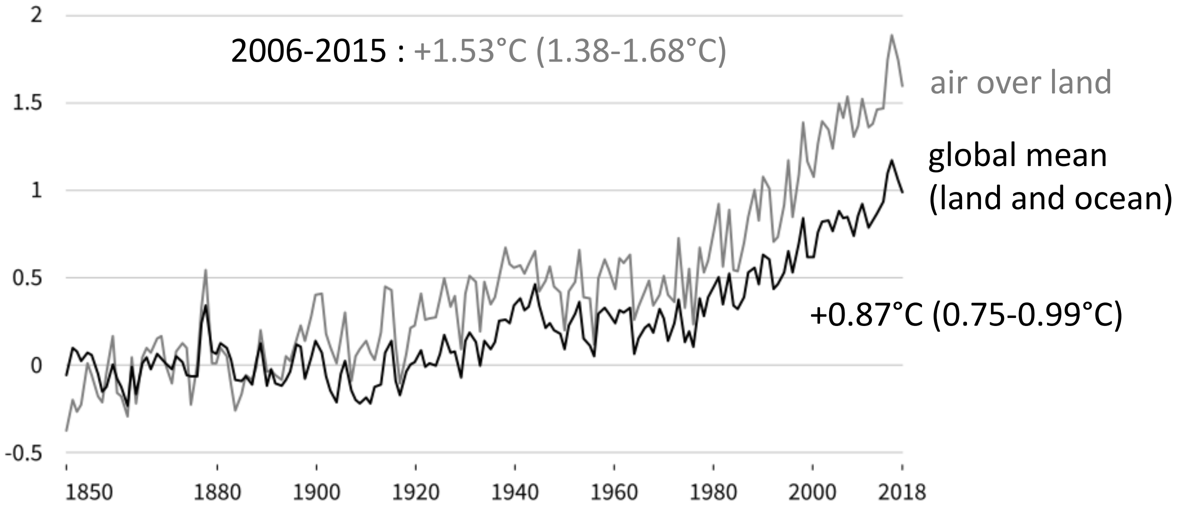
Climate Change is adding to these pressures

Temperature change at the Earth's surface since 1850-1900



INTERGOVERNMENTAL PANEL ON climate change

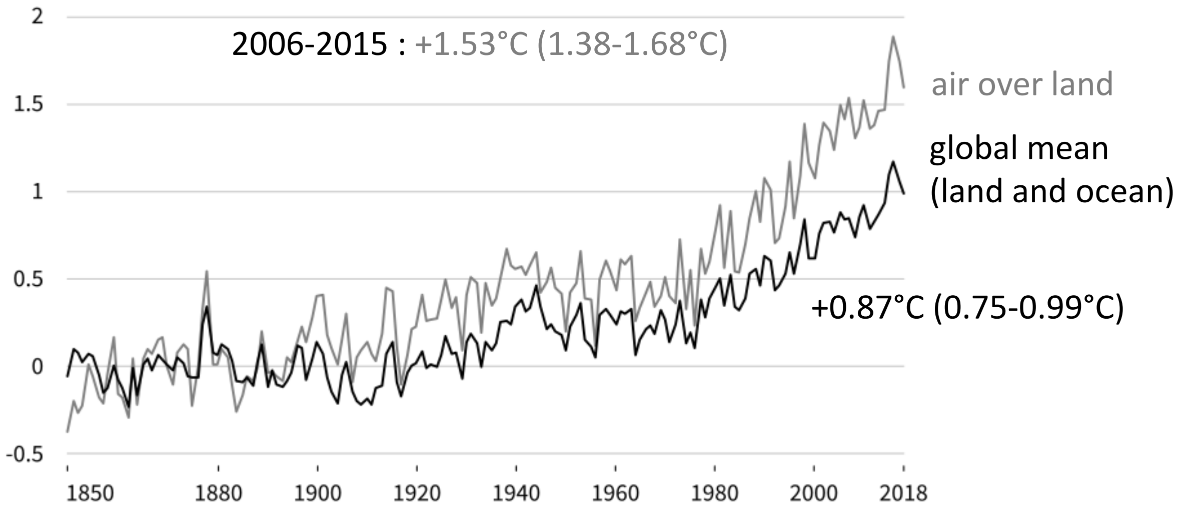
Climate Change is adding to these pressures

- ↗ Frequency, intensity and duration of heat waves
- ↗ Intensity of heavy rainfall events
- ↗ Frequency and intensity of drought (Mediterranean, West and NorthEast Asia, regions in South America and Africa)

Shifts of climate zones affecting many plant and animal species

Vegetation greening area > browning area

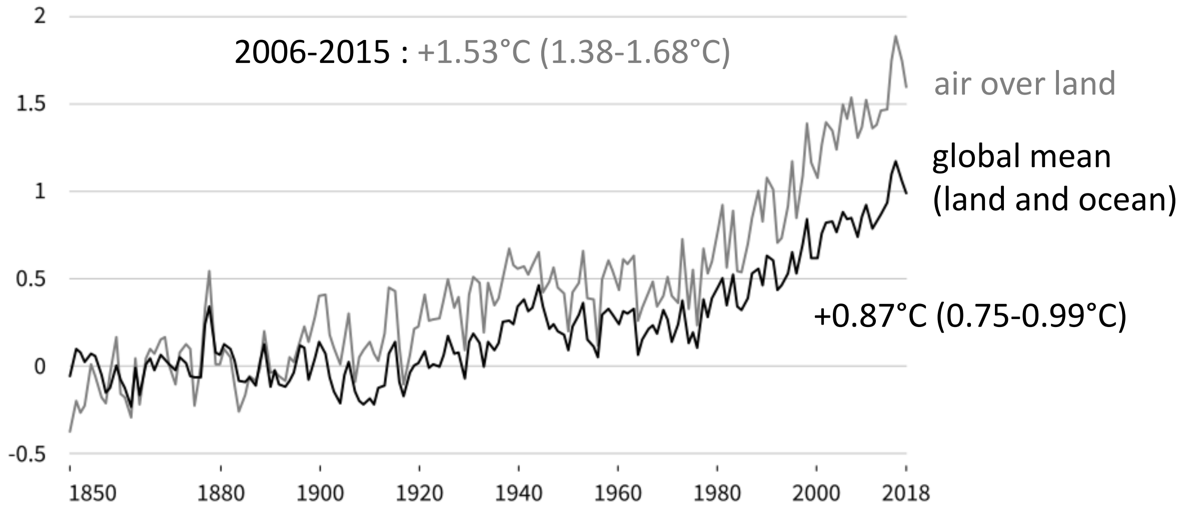
Temperature change at the Earth's surface since 1850-1900



Climate Change is adding to these pressures

- Annual area of drylands in drought by 1% per year since 1961
- Frequency and intensity of dust storms

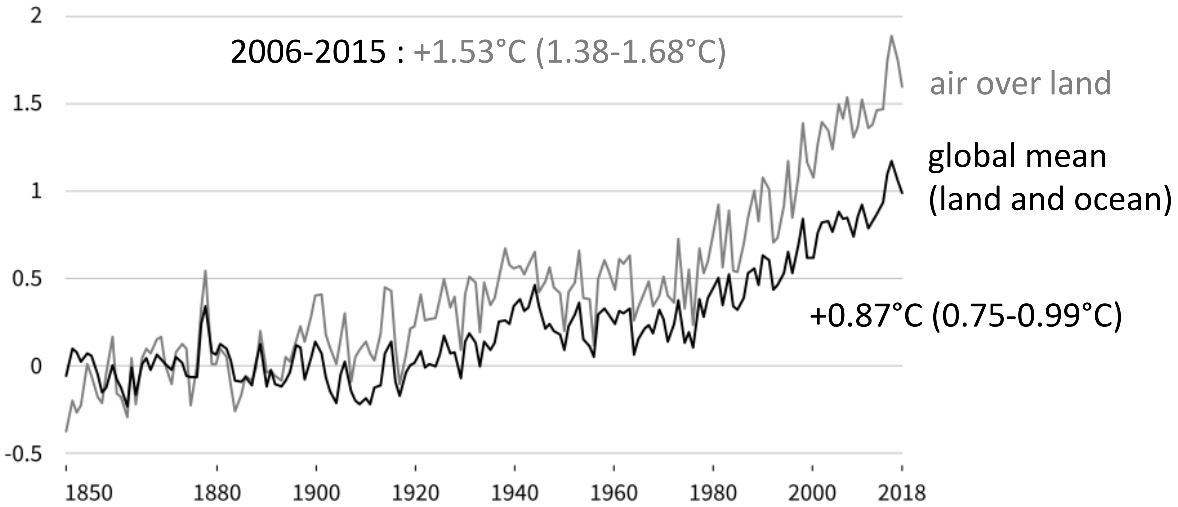
Temperature change at the Earth's surface since 1850-1900



Climate change exacerbates land degradation, particularly in low-lying coastal areas, river deltas, drylands and in permafrost areas due to changes in rainfall intensity, heat and water stress, permafrost thaw, coastal erosion and sea level rise.

Climate Change is adding to these pressures

Temperature change at the Earth's surface since 1850-1900



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The food system is under pressure and is vulnerable to climate change

- ↗ Per capita supply of food calories +1/3 since 1961
- ↗ Per capita consumption of vegetable oils and meat x2

- 821 million people still undernourished
  2 billion people now being overweight or obese

- 25 to 30 % of total food produced is lost or wasted

- Climate change is already affecting food security
  - ↘ *Yields of some crops in lower-latitude regions (ex. maize, wheat, barley)*
  - ↘ *Animal growth rates and productivity in pastoral systems in Africa*
  - ↗ *Yields of some crops (e.g. maize, wheat, sugar beet) in higher latitude regions*
  - *Agricultural pests and diseases and infestations*

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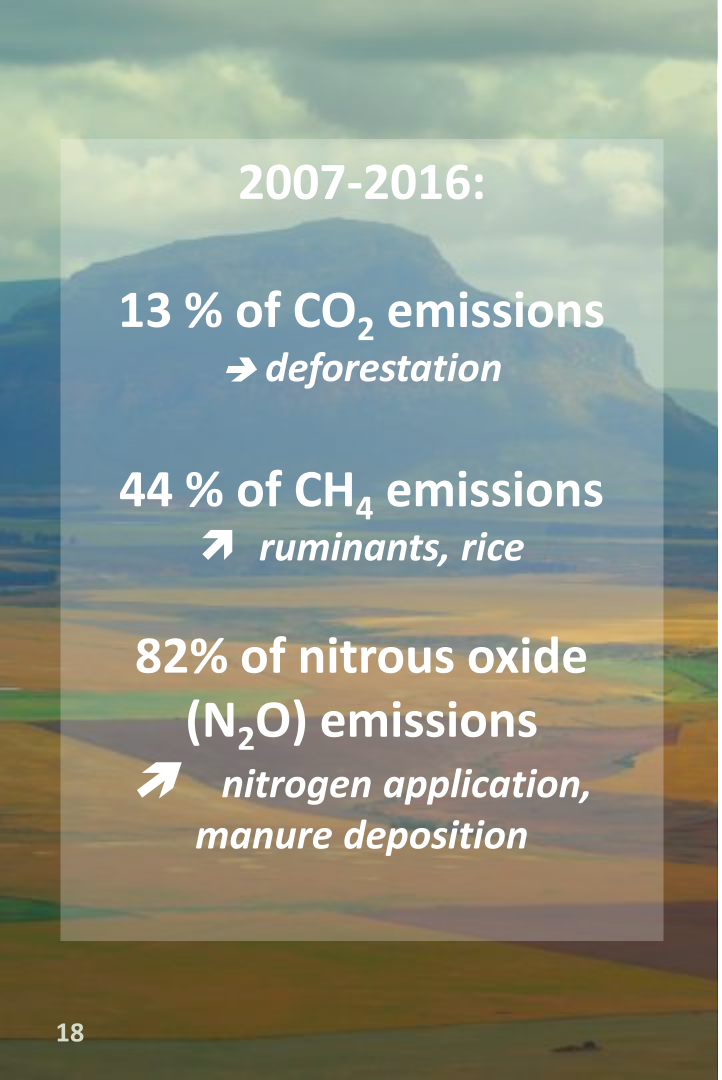

2007-2016:

13 % of CO_2 emissions

➔ *deforestation*

44 % of CH_4 emissions

↗ *ruminants, rice*

82% of nitrous oxide (N_2O) emissions

↗ *nitrogen application, manure deposition*

Agriculture, Forestry and Other Land Use account for around 23% of total net anthropogenic greenhouse gas emissions

Food system (including pre and post-production activities) : 21-37% of total net anthropogenic greenhouse gas emissions

- *Large regional differences*
- *Projected to increase driven by population and income growth, changes in consumption patterns*

Food loss and waste :

8 - 10 % of global greenhouse gas emission

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The natural response of land to human-induced environmental changes results in net removal of ~29 % of global anthropogenic CO_2 annual missions

- Future net increases in CO_2 emissions from vegetation and soils due to climate change are projected to counteract increased removals due to CO_2 fertilization and longer growing seasons. The balance between these processes is a key source uncertainty for determining the future of the land carbon sink.

- Projected thawing of permafrost is expected to increase the loss of soil carbon During the 21st century, vegetation growth in those areas may compensate in part for this loss.

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Changes in land conditions, either from land-use or climate change, affect global and regional climate

- At the regional scale, changing land conditions can reduce or accentuate warming and affect the intensity, frequency and direction of extreme events
- Drier (wetter) soil conditions can increase (reduce) the severity of heat waves
- When forest cover increases in tropical regions, cooling results from enhanced evapotranspiration.

INTERGOVERNMENTAL PANEL ON climate change

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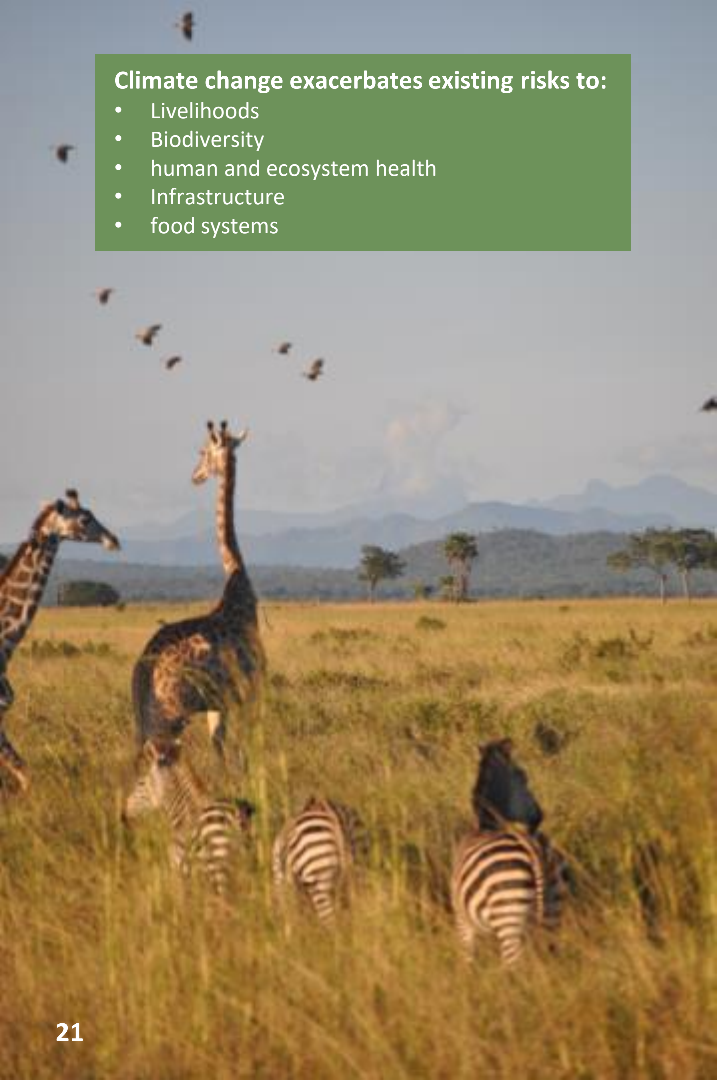


Climate change exacerbates existing risks to:

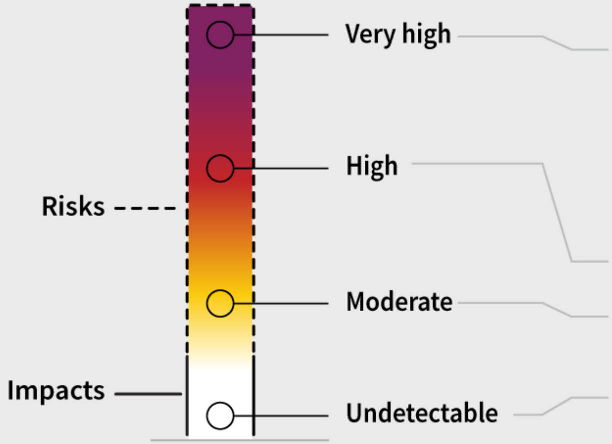
- Livelihoods
- Biodiversity
- human and ecosystem health
- Infrastructure
- food systems

Increasing impacts on land are projected under all future GHG emission scenarios.

- Some regions will face higher risks, while some regions will face risks previously not anticipated.
- With increasing warming, the frequency, intensity and duration of heat waves, droughts and rainfall are expected to increase in many regions.
- **Climate zones** are projected to further shift poleward in the middle and high latitudes.
- In **high-latitude regions**, warming is projected to increase disturbance in boreal forests, including drought, wildfire, and pest outbreaks.
- In **tropical regions**, under medium and high GHG emissions scenarios, warming is projected to result in the emergence of unprecedented climatic conditions by the mid to late 21st century.

SPM Figure 2 – C

Legend: **Level of impact/risk**



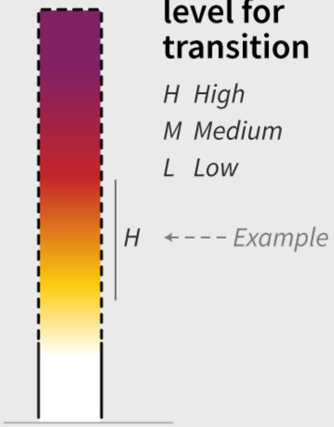
Purple: Very high probability of severe impacts/ risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.

Red: Significant and widespread impacts/risks.

Yellow: Impacts/risks are detectable and attributable to climate change with at least medium confidence.

White: Impacts/risks are undetectable.

Legend: **Confidence level for transition**

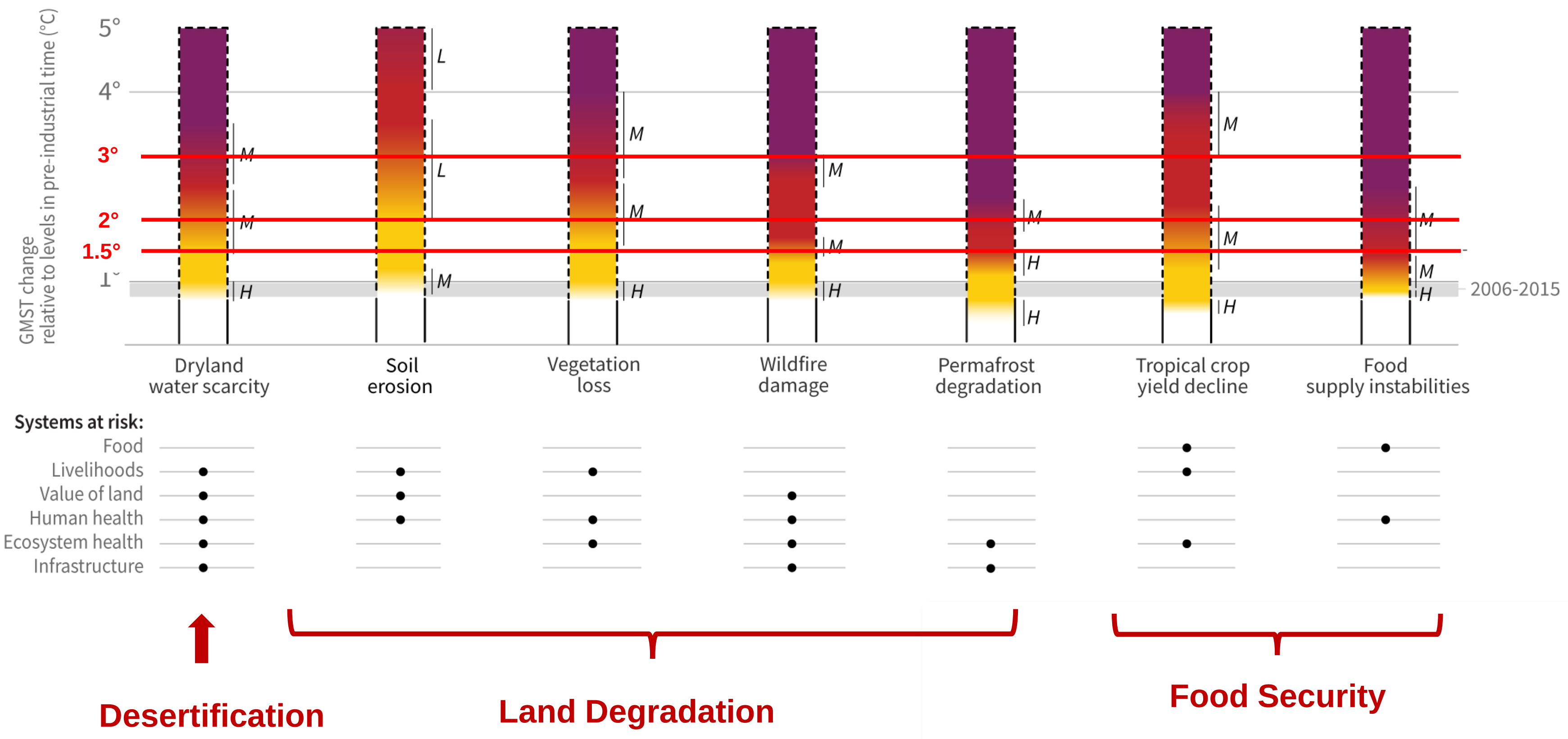


SPM Figure 2 – A - 2

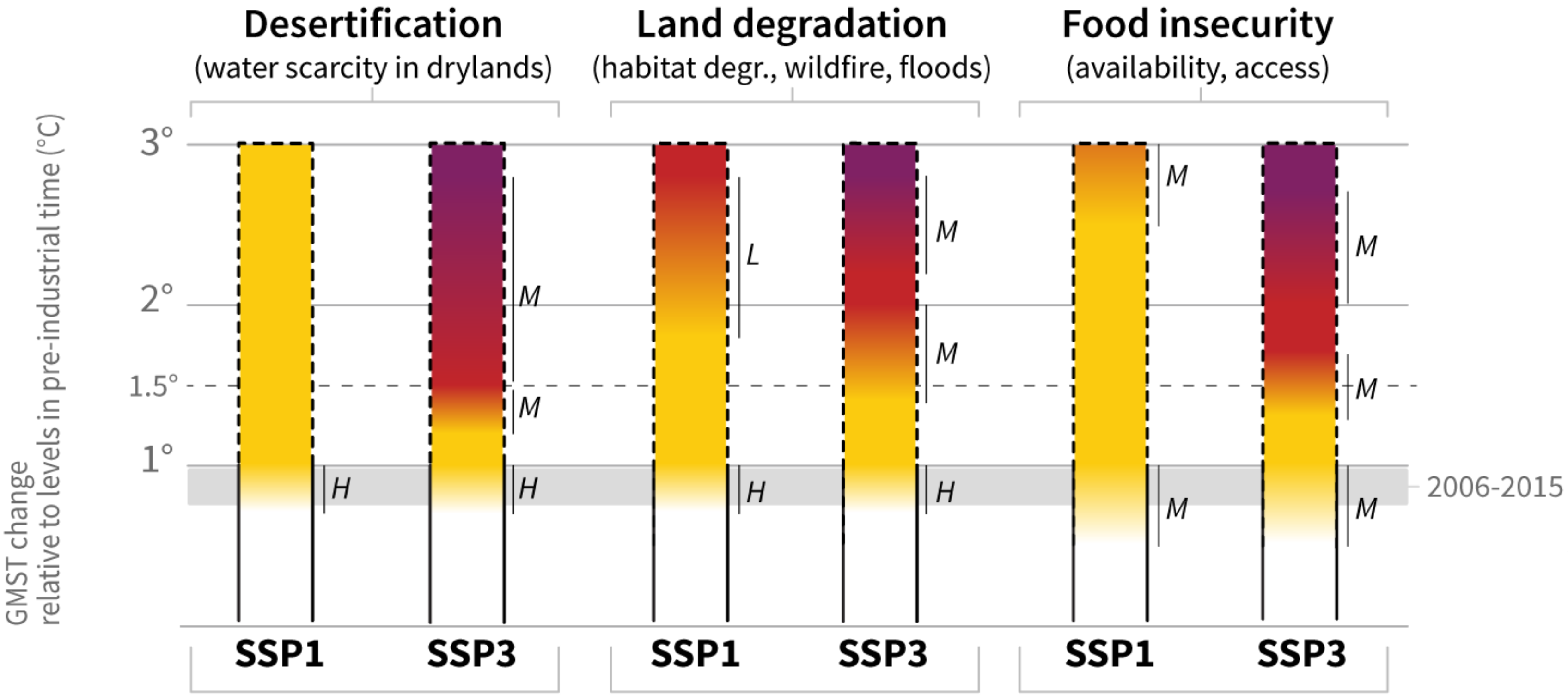
INTERGOVERNMENTAL PANEL ON climate change

SPM Figure 2 – A -1

The warming climate affects processes connected to desertification, land degradation, and food security, and increase their risks.



For the same level of warming, the level of risk depends on the choice of development



For the same level of warming, the level of risk depends on the choice of development

In SSP 1 there is low population growth, reduced inequalities, low emission production systems, efficient use of land, increased capacity for adaptation.

In SSP3 there is increased population and demand, increasing inequality, multiple pressures on land, low capacity for adaptation.

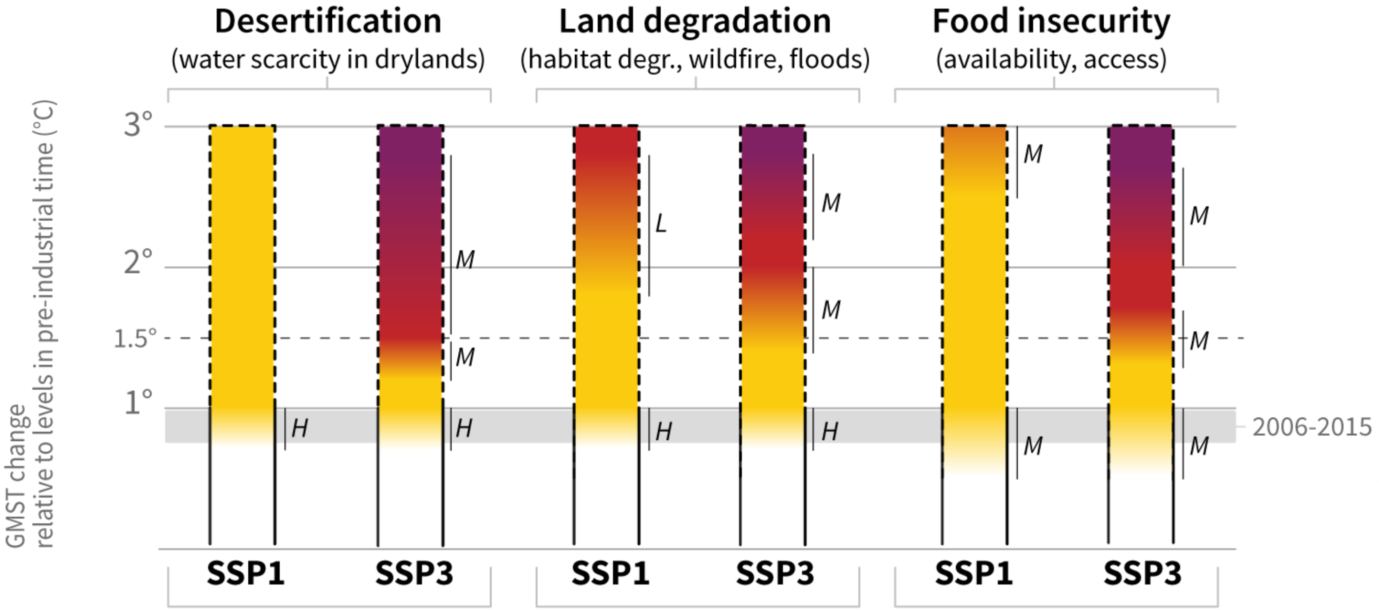
Vulnerabilities

The tropics and subtropics are projected to be most vulnerable to crop yield decline.

North America, South America, Mediterranean, southern Africa and central Asia may be increasingly affected by wildfire.

Asia and Africa are projected to have the highest number of people vulnerable to increased desertification.

The level of risk posed by climate change depends both on the level of warming and on how population, consumption, production, technological development, and land management patterns evolve.



The level of risk posed by climate change depends both on the level of warming and on how population, consumption, production, technological development, and land management patterns evolve.

- Pathways with increases in population and income result in increased demand for food, feed, and water in 2050 in all SSPs.

- Together with resource-intensive consumption and production, and limited technological improvements in agriculture yields this results in higher risks from water scarcity and food insecurity.

- These changes have implications for terrestrial GHG emissions, carbon sequestration potential, and biodiversity.

The level of risk posed by climate change depends both on the level of warming and on how population, consumption, production, technological development, and land management patterns evolve.

- Risks are higher in pathways with low adaptive capacity and other barriers to adaptation.

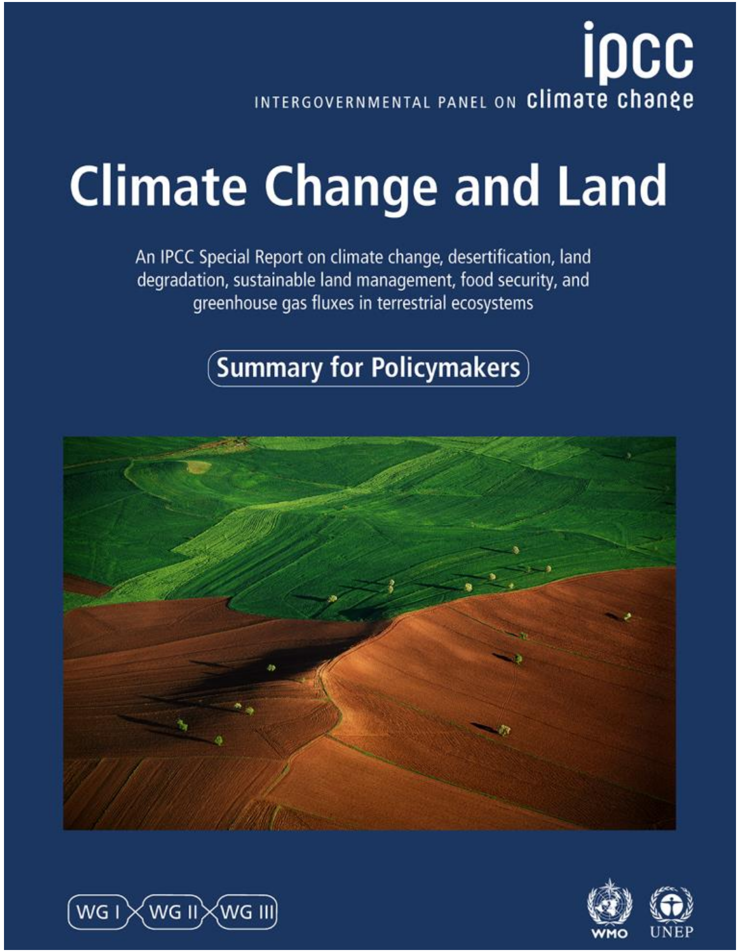
- Risks related to food security are greater in pathways with lower income, increased food demand, increased food prices resulting from e.g. competition for land, more limited trade.

- Urban expansion is projected to lead to conversion of cropland leading to losses in food production. This can result in additional risks to the food system.

CLIMATE CHANGE AND LAND

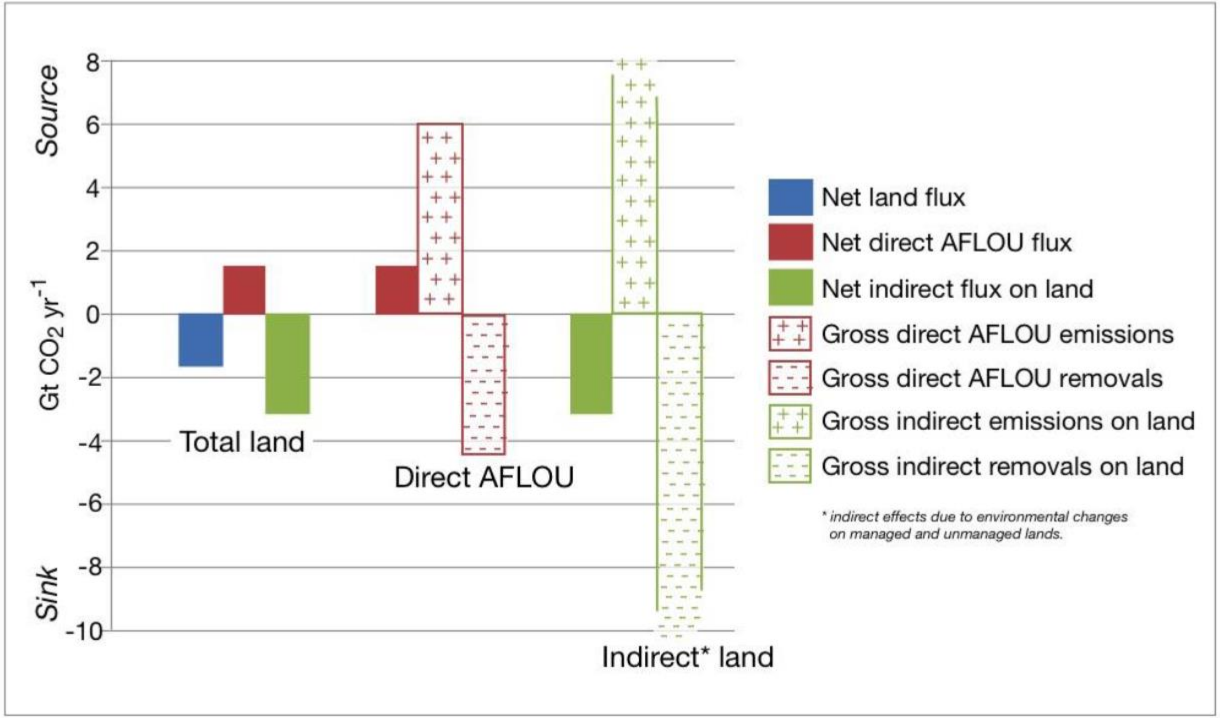
An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

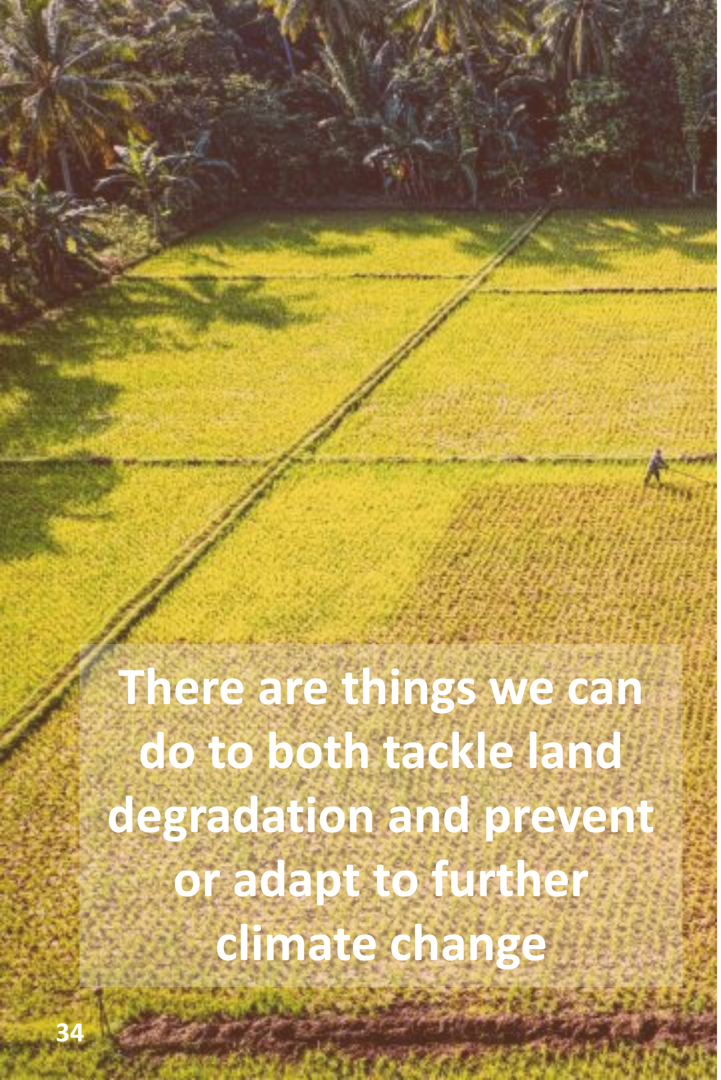
REPORT COVER IMAGE:
Agricultural landscape between Ankara and Hattusha, Anatolia, Turkey (40°00' N – 33°35' E)



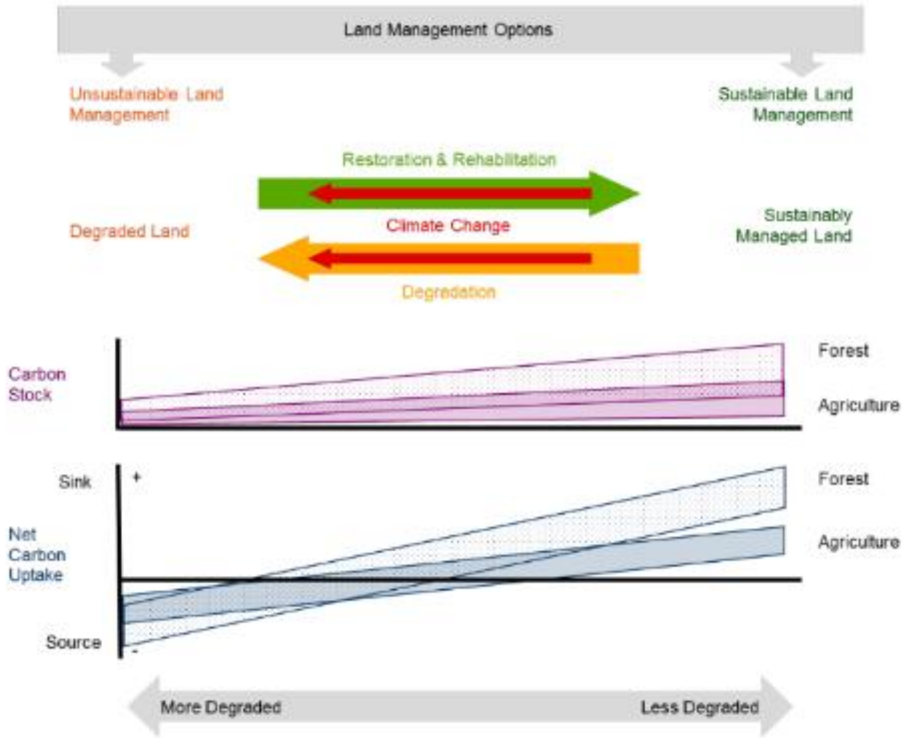
“ **Better land management can play its part** in tackling climate change, but it can’t do it all.

Land is simultaneously a source and a sink of CO2. It is a part of the problem and the solution!





There are things we can do to both tackle land degradation and prevent or adapt to further climate change

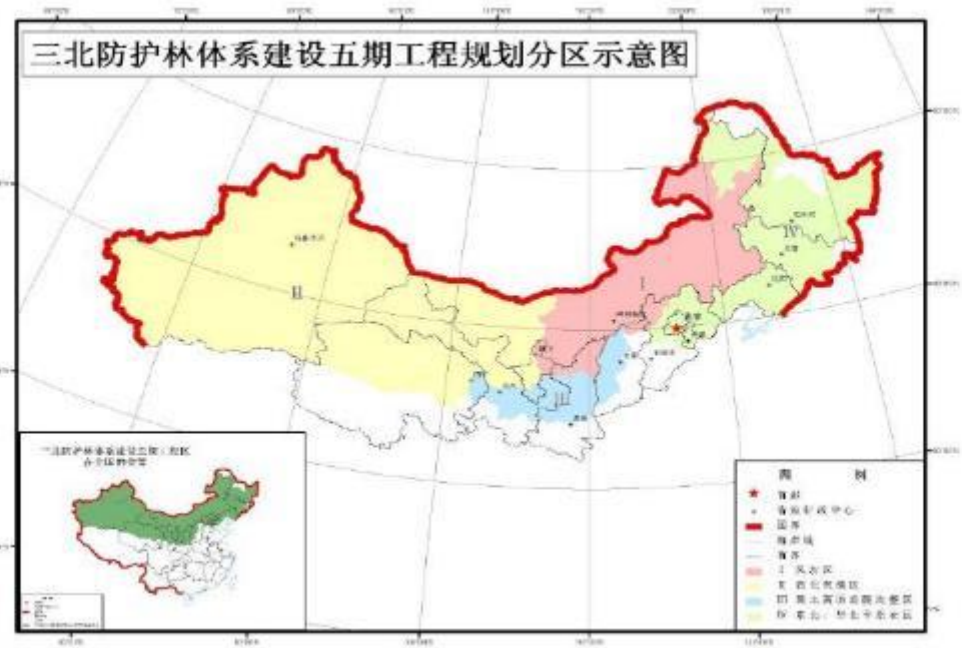


Sustainable land management can help reduce and sometime reverse these adverse impacts.

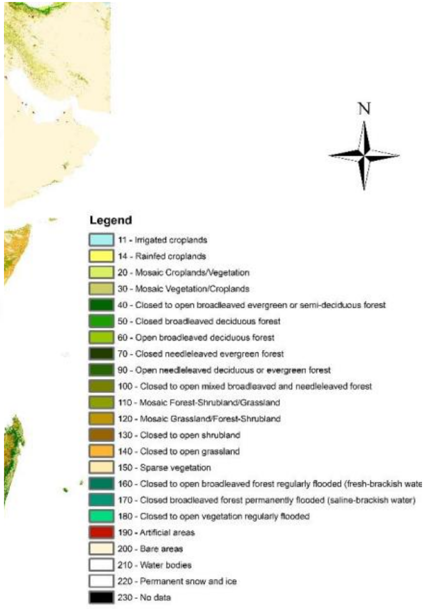
Many land-related responses that contribute to climate change adaptation and mitigation can also combat desertification and land degradation and enhance food security

Greer

Three North's Forest Shelterbelt programme in Northeast China, North China, and Northwest China



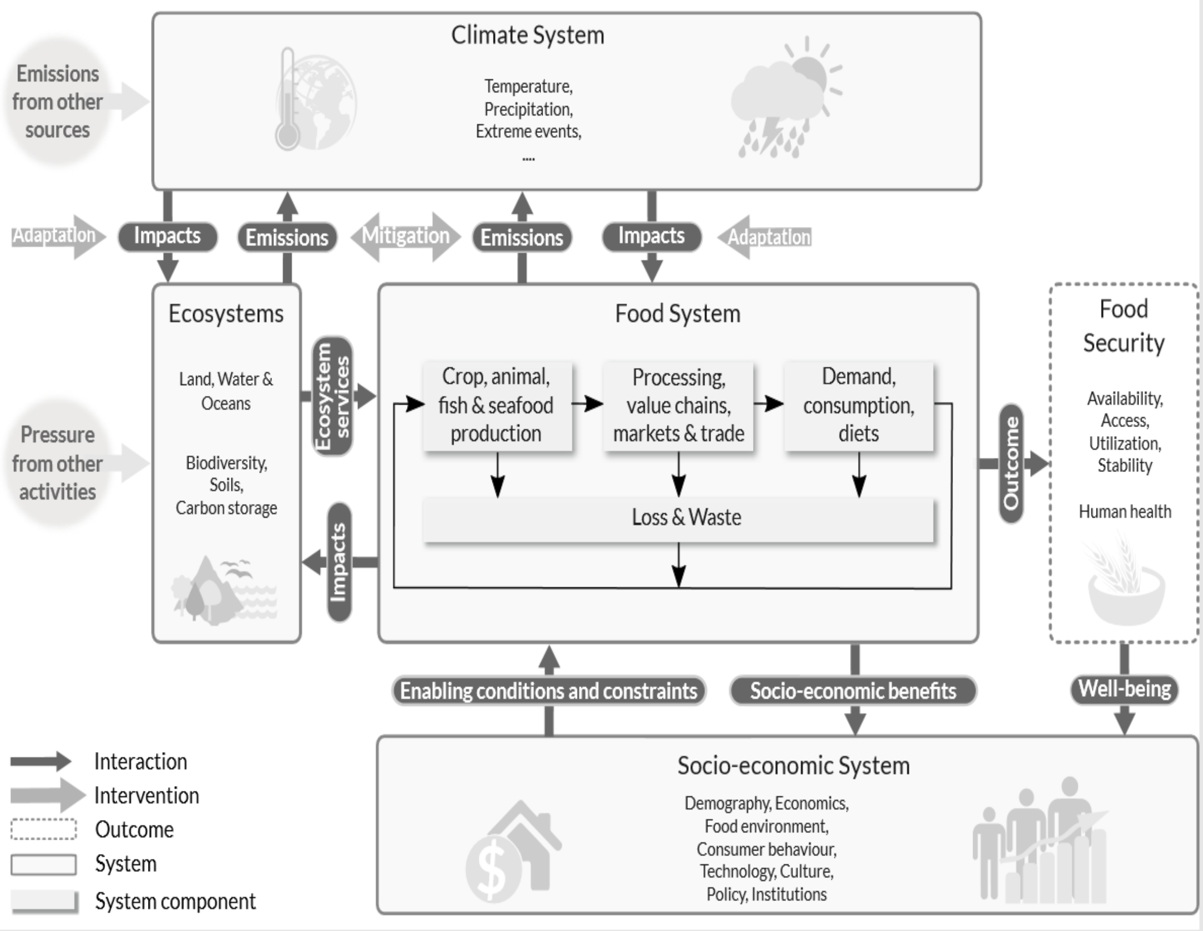
hara and the Sahel



ON climate change

The Food System

- **25-30%** of food produced is **lost or wasted**.
- Almost **half (41%)** of human-caused methane emissions come from livestock.
- Reducing this loss or waste can help **reduce greenhouse gas emissions** and **improve food security**.
- **Dietary changes** can reduce pressure on land and reduce emissions.



We didn't classify response options by mitigation/ adaptation: many options have multiple benefits

Responses by broad type

- Land management
- Value chain management
- Risk management

Responses by magnitude of impact (technical potential)

- > 3 Gt CO_2eq yr^{-1}
- 0.3 – 3 Gt CO_2eq yr^{-1}
- < 0.3 Gt CO_2eq yr^{-1}

Responses by impact on land competition

- No or limited competition for land
- Those that rely on additional land use change

Potential global contribution of response options to mitigation, adaptation, combating desertification and land degradation, and enhancing food security

Panel A shows response options that can be implemented without or with limited competition for land, including some that have the potential to reduce the demand for land. Co-benefits and adverse side effects are shown quantitatively based on the high end of the range of potentials assessed. Magnitudes of contributions are categorised using thresholds for positive or negative impacts. Letters within the cells indicate confidence in the magnitude of the impact relative to the thresholds used (see legend). Confidence in the direction of change is generally higher.

	Response options based on land management	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	- L	●
Forests	Forest management	M	L	L	L	L	●●
	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
	Reduced soil erosion	←→ L	L	M	M	L	●●
	Reduced soil salinization	—	L	L	L	L	●●
	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
	Reduced landslides and natural hazards	L	L	L	L	L	—
	Reduced pollution including acidification	←→ M	M	L	L	L	—
	Restoration & reduced conversion of coastal wetlands	M	L	M	M	←→ L	—
	Restoration & reduced conversion of peatlands	M	—	na	M	- L	●
	Response options based on value chain management						
Demand	Reduced post-harvest losses	H	M	L	L	H	—
	Dietary change	H	—	L	H	H	—
	Reduced food waste (consumer or retailer)	H	—	L	M	M	—
Supply	Sustainable sourcing	—	L	—	L	L	—
	Improved food processing and retailing	L	L	—	—	L	—
	Improved energy use in food systems	L	L	—	—	L	—
	Response options based on risk management						
Risk	Livelihood diversification	—	L	—	L	L	—
	Management of urban sprawl	—	L	L	M	L	—
	Risk sharing instruments	←→ L	L	—	←→ L	L	●●

Options shown are those for which data are available to assess global potential for three or more land challenges.
The magnitudes are assessed independently for each option and are not additive.

Key for criteria used to define magnitude of impact of each integrated response option

		Mitigation *Gt CO_2-eq yr^{-1}*	Adaptation *Million people*	Desertification *Million km^2*	Land Degradation *Million km^2*	Food Security *Million people*
Positive	Large	More than 3	Positive for more than 25	Positive for more than 3	Positive for more than 3	Positive for more than 100
	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Small	Less than 0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Negligible	No effect	No effect	No effect	No effect	No effect
Negative	Small	Less than -0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Moderate	-0.3 to -3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Large	More than -3	Negative for more than 25	Negative for more than 3	Negative for more than 3	Negative for more than 100

←→ **Variable:** Can be positive or negative — no data na not applicable

Confidence level

Indicates confidence in the estimate of magnitude category.

H High confidence
M Medium confidence
L Low confidence

Cost range

See technical caption for cost ranges in US$ tCO_2e^{-1} or US$ ha^{-1}.

●●● High cost
●● Medium cost
● Low cost
— no data

Response options classified into 3 Broad Types: Land Management, Value Chain Management , Risk Management

28 different response options can be implemented with **limited or no competition** for land.

Almost all response options have a positive effect on mitigation, adaptation, desertification, land degradation and **food security**.

Most land-based response options have a positive effect and co-benefits

Response options based on land management		Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	- L	●

INTERGOVERNMENTAL PANEL ON climate change

SPM Figure 3 – 1

Most land-based response options have a positive effect and co-benefits

	Response options based on land management	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Forests	Forest management	M	L	L	L	L	●●
Forests	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
Soils	Reduced soil erosion	⟷ L	L	M	M	L	●●
Soils	Reduced soil salinization	—	L	L	L	L	●●
Soils	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
Other ecosystems	Reduced landslides and natural hazards	L	L	L	L	L	—
Other ecosystems	Reduced pollution including acidification	⟷ M	M	L	L	L	—
Other ecosystems	Restoration & reduced conversion of coastal wetlands	M	L	M	M	⟷ L	—
Other ecosystems	Restoration & reduced conversion of peatlands	M	—	na	M	- L	●

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SPM Figure 3 – 1

All supply/demand and risk management based response options have a positive effect and many co-benefits

		Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Response options based on value chain management							
Demand	Reduced post-harvest losses	H	M	L	L	H	—
Demand	Dietary change	H	—	L	H	H	—
Demand	Reduced food waste (consumer or retailer)	H	—	L	M	M	—
Supply	Sustainable sourcing	—	L	—	L	L	—
Supply	Improved food processing and retailing	L	L	—	—	L	—
Supply	Improved energy use in food systems	L	L	—	—	L	—
Response options based on risk management							
Risk	Livelihood diversification	—	L	—	L	L	—
Risk	Management of urban sprawl	—	L	L	M	L	—
Risk	Risk sharing instruments	↔ L	L	—	↔ L	L	●●

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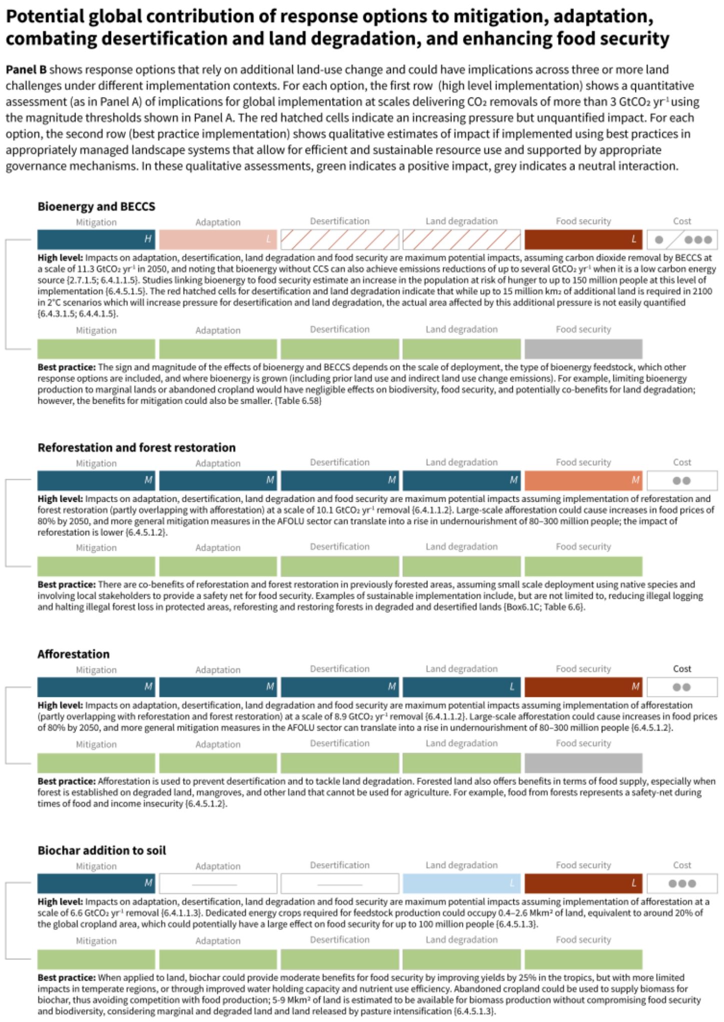


Potential global contribution of response options to mitigation, adaptation, combating desertification and land degradation, and enhancing food security

Panel B shows response options that rely on additional land-use change and could have implications across three or more land challenges under different implementation contexts. For each option, the first row (high level implementation) shows a quantitative assessment (as in Panel A) of implications for global implementation at scales delivering CO_2 removals of more than 3 $GtCO_2$ yr^{-1} using the magnitude thresholds shown in Panel A. The red hatched cells indicate an increasing pressure but unquantified impact. For each option, the second row (best practice implementation) shows qualitative estimates of impact if implemented using best practices in appropriately managed landscape systems that allow for efficient and sustainable resource use and supported by appropriate governance mechanisms. In these qualitative assessments, green indicates a positive impact, grey indicates a neutral interaction.

Bioenergy and BECCS

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2$ yr^{-1} in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2$ yr^{-1} when it is a low carbon energy source {2.7.1.5; 6.4.1.1.5}. Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation {6.4.5.1.5}. The red hatched cells for desertification and land degradation indicate that while up to 15 million km_2 of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified {6.4.3.1.5; 6.4.4.1.5}.

Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. {Table 6.58}

Reforestation and forest restoration

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2$ yr^{-1} removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.4.5.1.2}.

Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

Afforestation

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 $GtCO_2$ yr^{-1} removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people {6.4.5.1.2}.

Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during times of food and income insecurity {6.4.5.1.2}.

Biochar addition to soil

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation at a scale of 6.6 $GtCO_2$ yr^{-1} removal {6.4.1.1.3}. Dedicated energy crops required for feedstock production could occupy 0.4–2.6 Mkm^2 of land, equivalent to around 20% of the global cropland area, which could potentially have a large effect on food security for up to 100 million people {6.4.5.1.3}.

Best practice: When applied to land, biochar could provide moderate benefits for food security by improving yields by 25% in the tropics, but with more limited impacts in temperate regions, or through improved water holding capacity and nutrient use efficiency. Abandoned cropland could be used to supply biomass for biochar, thus avoiding competition with food production; 5-9 Mkm^2 of land is estimated to be available for biomass production without compromising food security and biodiversity, considering marginal and degraded land and land released by pasture intensification {6.4.5.1.3}.

SPM Figure 3B

We looked closely at four land-based response options involving land use change with high **mitigation** potential.

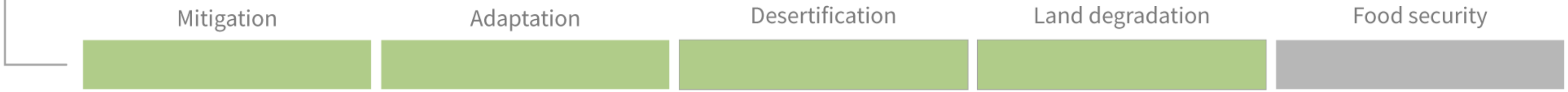
Their potential impacts on **adaptation, desertification, land degradation** and **food security** were assessed.

SPM Figure 3 – 3

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Bioenergy and BECCS

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2$ yr^{-1} in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2$ yr^{-1} when it is a low carbon energy source {2.7.1.5; 6.4.1.1.5}. Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation {6.4.5.1.5}. The red hatched cells for desertification and land degradation indicate that while up to 15 million km_2 of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified {6.4.3.1.5; 6.4.4.1.5}.

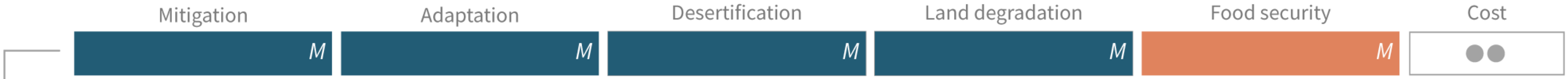


Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. {Table 6.58}

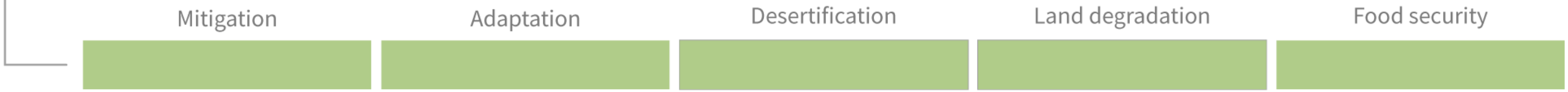
SPM Figure 3 – 4

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Reforestation and forest restoration



High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2$ yr^{-1} removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.4.5.1.2}.



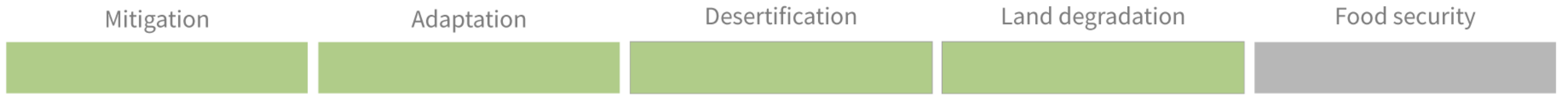
Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

SPM Figure 3 – 5

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Afforestation

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 $GtCO_2$ yr^{-1} removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people {6.4.5.1.2}.

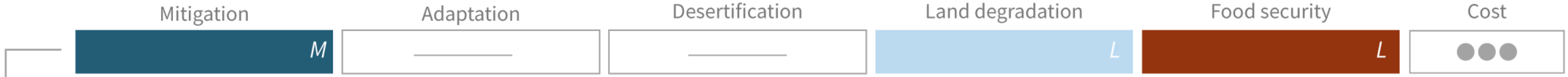


Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during times of food and income insecurity {6.4.5.1.2}.

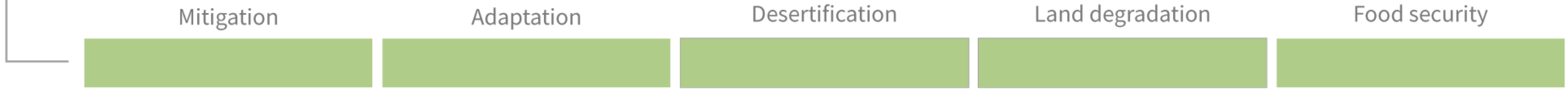
SPM Figure 3 – 6

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Biochar addition to soil



High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation at a scale of 6.6 $GtCO_2$ yr^{-1} removal {6.4.1.1.3}. Dedicated energy crops required for feedstock production could occupy 0.4–2.6 Mkm^2 of land, equivalent to around 20% of the global cropland area, which could potentially have a large effect on food security for up to 100 million people {6.4.5.1.3}.

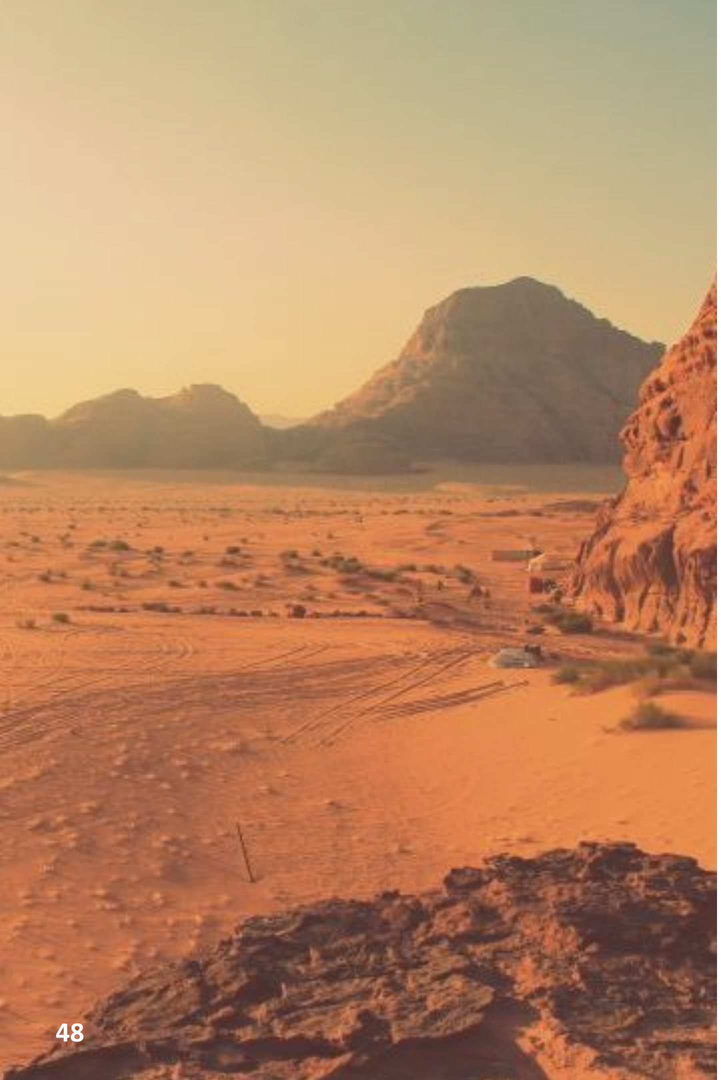


Best practice: When applied to land, biochar could provide moderate benefits for food security by improving yields by 25% in the tropics, but with more limited impacts in temperate regions, or through improved water holding capacity and nutrient use efficiency. Abandoned cropland could be used to supply biomass for biochar, thus avoiding competition with food production; 5-9 Mkm^2 of land is estimated to be available for biomass production without compromising food security and biodiversity, considering marginal and degraded land and land released by pasture intensification {6.4.5.1.3}.

Co-benefits

- Response options are **site** and **regionally specific**
- Activities that combat desertification can contribute to adaptation with mitigation co-benefits and can halt biodiversity loss
- Solutions that help adapt to and mitigate climate change while contributing to combating desertification include water harvesting and micro-irrigation, using drought-resilient ecologically appropriate plants, and agroforestry
- Avoiding, reducing and reversing land degradation in rangelands, croplands and forests can help to **eradicate poverty** and ensure **food security**

INTERGOVERNMENTAL PANEL ON climate change



Combatting Degradation and Desertification

- Reducing deforestation and forest degradation lowers GHG emissions and can contribute to adaptation goals
- Sustainable land management can prevent, reduce and in some cases reverse land degradation.
- Climate change can lead to land degradation, even with the implementation of measures intended to avoid, reduce or reverse land degradation
- Technological solutions are available to avoid, reduce and reverse desertification while also contributing to climate change mitigation and adaptation.
- Investment in sustainable land management and land restoration in drylands has positive economic returns.
- Indigenous and local knowledge can often enhance resilience to climate change and combat desertification.
- Preventing desertification is preferable to restoration of degraded land.

Response options throughout the food system can be deployed and scaled up to advance adaptation and mitigation

- The total technical mitigation potential from crop and livestock activities, and agroforestry is estimated as 2.3-9.6 $GtCO_2e.yr^{-1}$ by 2050.
- The total technical mitigation potential of dietary changes is estimated as 0.7-8 $GtCO_2e.yr^{-1}$ by 2050.
- Diversification in the food system can reduce risks from climate change.

INTERGOVERNMENTAL PANEL ON climate change

Dietary Choices

- **Balanced diets**, featuring plant-based foods, produced in resilient, sustainable and low-GHG emission systems, present **major opportunities** for **adaptation and mitigation** while generating significant co-benefits in terms of **human health**.

- Transitions towards **low-GHG emission diets** may be influenced by local production practices, technical and financial barriers and associated livelihoods and cultural habits.

Food loss and waste

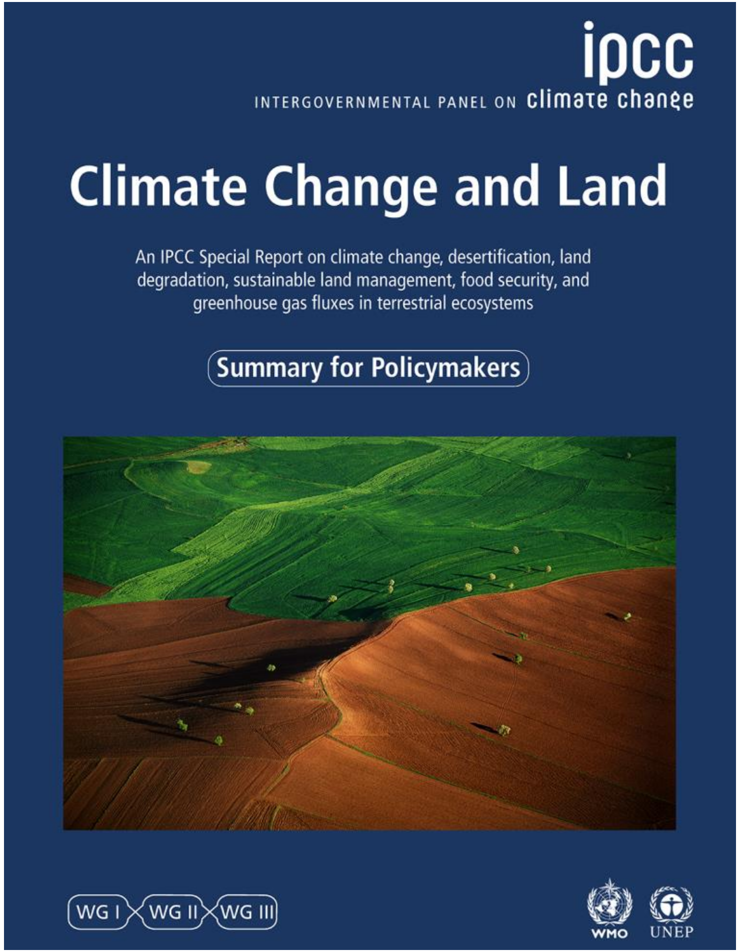
- Global food loss and waste accounts for 8-10% of total anthropogenic GHG emissions. 25-30% of food produced is lost or wasted. Causes of food loss and waste differ substantially between developed and developing countries, as well as between regions.

- Reduction of **food loss** and **waste** can lower GHG emissions and contribute to adaptation through reduction in the land area needed for food production.

- **Technical options** such as improved harvesting techniques, on-farm storage, infrastructure, transport, packaging, retail and education can reduce food loss and waste across the supply chain.

CLIMATE CHANGE AND LAND

An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.



REPORT COVER IMAGE:
Agricultural landscape between Ankara and Hattusha, Anatolia, Turkey (40°00' N – 33°35' E)
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“ Enabling **Response Options** and Near-term **Action**

policy design

Appropriate design of policies, institutions and governance systems at **all scales** can contribute to land-related adaptation and mitigation while facilitating the pursuit of **climate-adaptive development pathways**.

Mutually supportive climate and land policies have the potential to **save resources**, amplify social **resilience**, support ecological **restoration**, and foster engagement and **collaboration** between multiple stakeholders.

food & land policy

- Policies that operate across the food system, including those that reduce **food loss** and **waste** and influence **dietary choices**, enable more sustainable land-use management, enhanced food security and **low emissions** trajectories.

- Such policies can contribute to climate change **adaptation** and **mitigation**, reduce land degradation, desertification and poverty as well as improve **public health**.

- The adoption of sustainable land management and poverty eradication can be enabled by:
  - *improving access to markets*
  - *securing land tenure*
  - *factoring environmental costs into food*
  - *making payments for ecosystem services*
  - *enhancing local and community collective action*

integrated policy

- Acknowledging co-benefits and trade-offs when **designing** land and food **policies** can **overcome barriers** to implementation.
- Strengthened **multilevel**, hybrid and cross-sectoral governance, as well as policies developed and adopted in an iterative, coherent, adaptive and flexible manner can **maximise co-benefits** and **minimise trade-offs**
- This is because land management decisions are made from **farm level to national scales**, and both climate and land policies often range across **multiple** sectors, departments and agencies.
- Integration **across sectors** and **scales** increases the chance of **maximising co-benefits** and **minimising trade-offs**.

involving people

- The effectiveness of decision-making and governance is **enhanced** by the **involvement of local stakeholders** in the selection, evaluation, implementation and monitoring of policy instruments for land based climate change adaptation and mitigation.

- This applies particularly to those **most vulnerable to climate change**, including indigenous peoples and local communities, women, and the poor and marginalised.

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SPM Figure 4 A

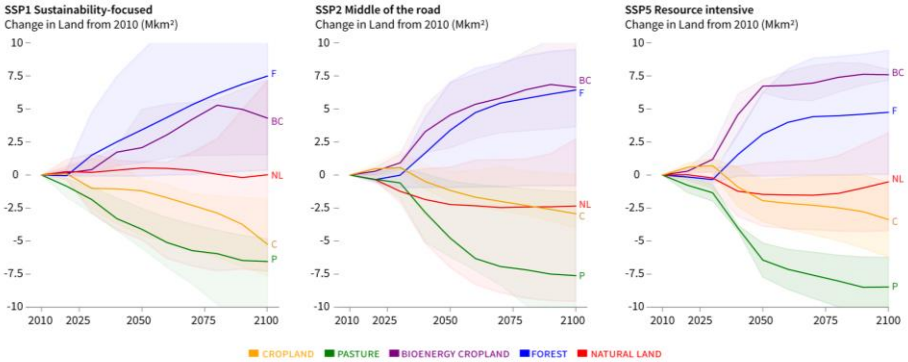
A. Pathways linking socioeconomic development, mitigation responses and land

Socioeconomic development and land management influence the evolution of the land system including the relative amount of land allocated to CROPLAND, PASTURE, BIOENERGY CROPLAND, FOREST, and NATURAL LAND. The lines show the median across Integrated Assessment Models (IAMs) for three alternative shared socioeconomic pathways (**SSP1**, **SSP2** and **SSP5** at **RCP1.9**); shaded areas show the range across models. Note that pathways illustrate the effects of climate change mitigation but not those of climate change impacts or adaptation.

A. Sustainability-focused (SSP1)
Sustainability in land management, agricultural intensification, production and consumption patterns result in reduced need for agricultural land, despite increases in per capita food consumption. This land can instead be used for reforestation, afforestation, and bioenergy.

B. Middle of the road (SSP2)
Societal as well as technological development follows historical patterns. Increased demand for land mitigation options such as bioenergy, reduced deforestation or afforestation decreases availability of agricultural land for food, feed and fibre.

C. Resource intensive (SSP5)
Resource-intensive production and consumption patterns, results in high baseline emissions. Mitigation focuses on technological solutions including substantial bioenergy and BECCS . Intensification and competing land uses contribute to declines in agricultural land.



We looked at the **influences/change to** land cover due to different **land-management approaches** over time.

Three pathways were looked at.

All were for global warming of 1.5 degrees (RCP1.9).

B. Land use and land cover change in the SSPs

	Quantitative indicators for the SSPs	Count of models included*	Change in Natural Land from 2010 Mkm²	Change in Bioenergy Cropland from 2010 Mkm²	Change in Cropland from 2010 Mkm²	Change in Forest from 2010 Mkm²	Change in Pasture from 2010 Mkm²
SSP1	RCP1.9 in 2050	5/5	0.5 (-4.9, 1)	2.1 (0.9, 5)	-1.2 (-4.6, -0.3)	3.4 (-0.1, 9.4)	-4.1 (-5.6, -2.5)
	↳ 2100		0 (-7.3, 7.1)	4.3 (1.5, 7.2)	-5.2 (-7.6, -1.8)	7.5 (0.4, 15.8)	-6.5 (-12.2, -4.8)
	RCP2.6 in 2050	5/5	-0.9 (-2.2, 1.5)	1.3 (0.4, 1.9)	-1 (-4.7, 1)	2.6 (-0.1, 8.4)	-3 (-4, -2.4)
	↳ 2100		0.2 (-3.5, 1.1)	5.1 (1.6, 6.3)	-3.2 (-7.7, -1.8)	6.6 (-0.1, 10.5)	-5.5 (-9.9, -4.2)
	RCP4.5 in 2050	5/5	0.5 (-1, 1.7)	0.8 (0.5, 1.3)	0.1 (-3.2, 1.5)	0.6 (-0.7, 4.2)	-2.4 (-3.3, -0.9)
	↳ 2100		1.8 (-1.7, 6)	1.9 (1.4, 3.7)	-2.3 (-6.4, -1.6)	3.9 (0.2, 8.8)	-4.6 (-7.3, -2.7)
	Baseline in 2050	5/5	0.3 (-1.1, 1.8)	0.5 (0.2, 1.4)	0.2 (-1.6, 1.9)	-0.1 (-0.8, 1.1)	-1.5 (-2.9, -0.2)
	↳ 2100		3.3 (-0.3, 5.9)	1.8 (1.4, 2.4)	-1.5 (-5.7, -0.9)	0.9 (0.3, 3)	-2.1 (-7, 0)
SSP2	RCP1.9 in 2050	4/5	-2.2 (-7, 0.6)	4.5 (2.1, 7)	-1.2 (-2, 0.3)	3.4 (-0.9, 7)	-4.8 (-6.2, -0.4)
	↳ 2100		-2.3 (-9.6, 2.7)	6.6 (3.6, 11)	-2.9 (-4, 0.1)	6.4 (-0.8, 9.5)	-7.6 (-11.7, -1.3)
	RCP2.6 in 2050	5/5	-3.2 (-4.2, 0.1)	2.2 (1.7, 4.7)	0.6 (-1.9, 1.9)	1.6 (-0.9, 4.2)	-1.4 (-3.7, 0.4)
	↳ 2100		-5.2 (-7.2, 0.5)	6.9 (2.3, 10.8)	-1.4 (-4, 0.8)	5.6 (-0.9, 5.9)	-7.2 (-8, 0.5)
	RCP4.5 in 2050	5/5	-2.2 (-2.2, 0.7)	1.5 (0.1, 2.1)	1.2 (-0.9, 2.7)	-0.9 (-2.5, 2.9)	-0.1 (-2.5, 1.6)
	↳ 2100		-3.4 (-4.7, 1.5)	4.1 (0.4, 6.3)	0.7 (-2.6, 3.1)	-0.5 (-3.1, 5.9)	-2.8 (-5.3, 1.9)
	Baseline in 2050	5/5	-1.5 (-2.6, -0.2)	0.7 (0, 1.5)	1.3 (1, 2.7)	-1.3 (-2.5, -0.4)	-0.1 (-1.2, 1.6)
	↳ 2100		-2.1 (-5.9, 0.3)	1.2 (0.1, 2.4)	1.9 (0.8, 2.8)	-1.3 (-2.7, -0.2)	-0.2 (-1.9, 2.1)
SSP3	RCP1.9 in 2050	Infeasible in all assessed models		-	-	-	-
	↳ 2100			-	-	-	-
	RCP2.6 in 2050	Infeasible in all assessed models		-	-	-	-
	↳ 2100			-	-	-	-
	RCP4.5 in 2050	3/3	-3.4 (-4.4, -2)	1.3 (1.3, 2)	2.3 (1.2, 3)	-2.4 (-4, -1)	2.1 (-0.1, 3.8)
	↳ 2100		-6.2 (-6.8, -5.4)	4.6 (1.5, 7.1)	3.4 (1.9, 4.5)	-3.1 (-5.5, -0.3)	2 (-2.5, 4.4)
	Baseline in 2050	4/4	-3 (-4.6, -1.7)	1 (0.2, 1.5)	2.5 (1.5, 3)	-2.5 (-4, -1.5)	2.4 (0.6, 3.8)
	↳ 2100		-5 (-7.1, -4.2)	1.1 (0.9, 2.5)	5.1 (3.8, 6.1)	-5.3 (-6, -2.6)	3.4 (0.9, 6.4)
SSP4	RCP1.9 in 2050	Infeasible in all assessed models**		-	-	-	-
	↳ 2100			-	-	-	-
	RCP2.6 in 2050	3/3	-4.5 (-6, -2.1)	3.3 (1.5, 4.5)	0.5 (-0.1, 0.9)	0.7 (-0.3, 2.2)	-0.6 (-0.7, 0.1)
	↳ 2100		-5.8 (-10.2, -4.7)	2.5 (2.3, 15.2)	-0.8 (-0.8, 1.8)	1.4 (-1.7, 4.1)	-1.2 (-2.5, -0.2)
	RCP4.5 in 2050	3/3	-2.7 (-4.4, -0.4)	1.7 (1, 1.9)	1.1 (-0.1, 1.7)	-1.8 (-2.3, 2.1)	0.8 (-0.5, 1.5)
	↳ 2100		-2.8 (-7.8, -2)	2.7 (2.3, 4.7)	1.1 (0.2, 1.2)	-0.7 (-2.6, 1)	1.4 (-1, 1.8)
	Baseline in 2050	3/3	-2.8 (-2.9, -0.2)	1.1 (0.7, 2)	1.1 (0.7, 1.8)	-1.8 (-2.3, -1)	1.5 (-0.5, 2.1)
	↳ 2100		-2.4 (-5, -1)	1.7 (1.4, 2.6)	1.2 (1.2, 1.9)	-2.4 (-2.5, -2)	1.3 (-1, 4.4)
SSP5	RCP1.9 in 2050	2/4	-1.5 (-3.9, 0.9)	6.7 (6.2, 7.2)	-1.9 (-3.5, -0.4)	3.1 (-0.1, 6.3)	-6.4 (-7.7, -5.1)
	↳ 2100		-0.5 (-4.2, 3.2)	7.6 (7.2, 8)	-3.4 (-6.2, -0.5)	4.7 (0.1, 9.4)	-8.5 (-10.7, -6.2)
	RCP2.6 in 2050	4/4	-3.4 (-6.9, 0.3)	4.8 (3.8, 5.1)	-2.1 (-4, 1)	3.9 (-0.1, 6.7)	-4.4 (-5, 0.2)
	↳ 2100		-4.3 (-8.4, 0.5)	9.1 (7.7, 9.2)	-3.3 (-6.5, -0.5)	3.9 (-0.1, 9.3)	-6.3 (-9.1, -1.4)
	RCP4.5 in 2050	4/4	-2.5 (-3.7, 0.2)	1.7 (0.6, 2.9)	0.6 (-3.3, 1.9)	-0.1 (-1.7, 6)	-1.2 (-2.6, 2.3)
	↳ 2100		-4.1 (-4.6, 0.7)	4.8 (2, 8)	-1 (-5.5, 1)	-0.2 (-1.4, 9.1)	-3 (-5.2, 2.1)
	Baseline in 2050	4/4	-0.6 (-3.8, 0.4)	0.8 (0, 2.1)	1.5 (-0.7, 3.3)	-1.9 (-3.4, 0.5)	-0.1 (-1.5, 2.9)
	↳ 2100		-0.2 (-2.4, 1.8)	1 (0.2, 2.3)	1 (-2, 2.5)	-2.1 (-3.4, 1.1)	-0.4 (-2.4, 2.8)

*Count of models included / Count of models attempted. One model did not provide land data and is excluded from all entries.

** One model could reach RCP1.9 with SSP4, but did not provide land data

SPM Figure 4 B

We then looked at 5 different **pathways** (including SSP1, SSP2 and SSP5).

For each pathway we analysed the **change in amount of land cover** for **each type of land** from **a 2010 baseline for both 2050 to 2100.**

This was completed for global warming scenarios of **1.5 degrees** (RCP1.9), **2 degrees** (RCP2.6), and **3 degrees** (RCP4.5).

Change in Natural Land from 2010 Mkm²

Change in Bioenergy Cropland from 2010 Mkm²

Change in Cropland from 2010 Mkm²

Change in Forest from 2010 Mkm²

Change in Pasture from 2010 Mkm²

SPM Figure 4 B

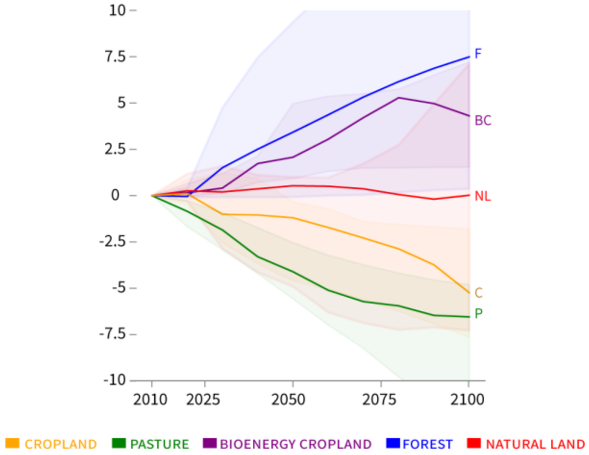
The types of land included…

SPM Figure 4A – A/B

A more sustainable pathway means less need bioenergy cropland in 2100 and a more gradual increase in forest land.

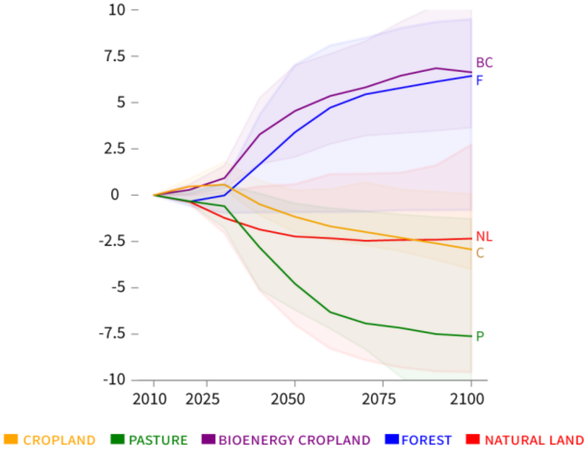
A. Sustainability-focused (SSP1)
Sustainability in land management, agricultural intensification, production and consumption patterns result in reduced need for agricultural land, despite increases in per capita food consumption. This land can instead be used for reforestation, afforestation, and bioenergy.

SSP1 Sustainability-focused
Change in Land from 2010 (Mkm²)



B. Middle of the road (SSP2)
Societal as well as technological development follows historical patterns. Increased demand for land mitigation options such as bioenergy, reduced deforestation or afforestation decreases availability of agricultural land for food, feed and fibre.

SSP2 Middle of the road
Change in Land from 2010 (Mkm²)



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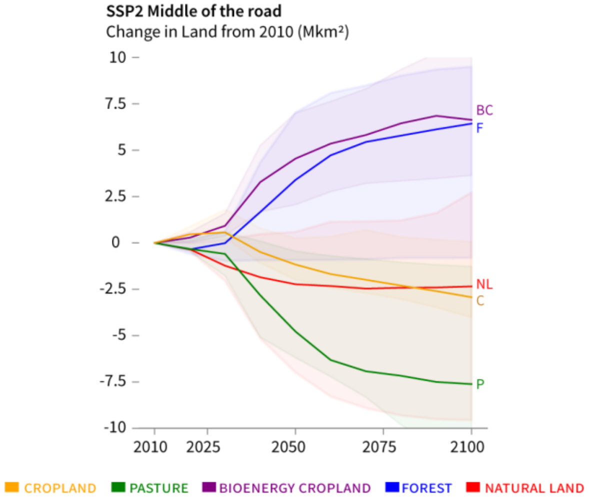
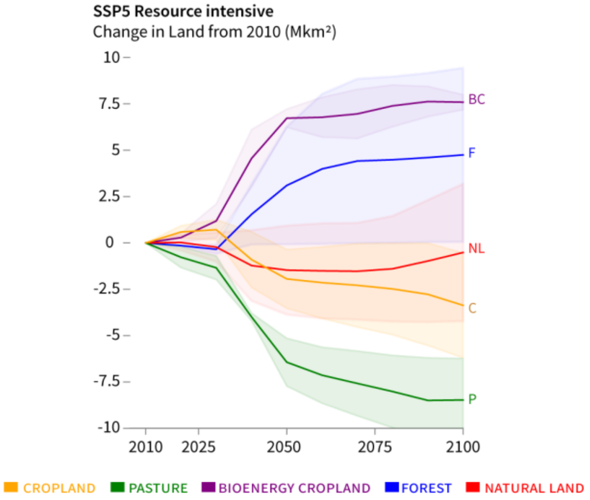
SPM Figure 4A – B/C

A resource intensive pathway means a more dramatic increase in bioenergy cropland by 2050.

B. Middle of the road (SSP2)
Societal as well as technological development follows historical patterns. Increased demand for land mitigation options such as bioenergy, reduced deforestation or afforestation decreases availability of agricultural land for food, feed and fibre.



C. Resource intensive (SSP5)
Resource-intensive production and consumption patterns, results in high baseline emissions. Mitigation focuses on technological solutions including substantial bioenergy and BECCS . Intensification and competing land uses contribute to declines in agricultural land.



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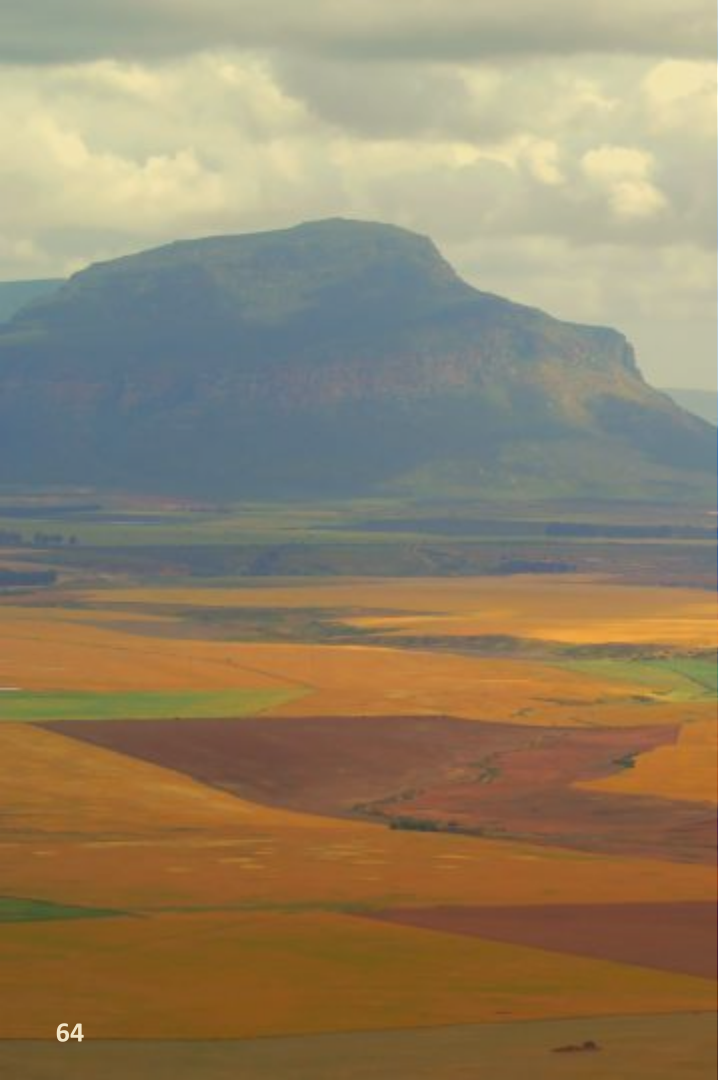
Near-term Action

- Actions can be taken in the near-term, based on **existing knowledge**, to address desertification, land degradation and food security while supporting longer-term responses that enable adaptation and mitigation to climate change.

- These include actions to:
  - *build individual and institutional capacity*
  - *accelerate knowledge transfer*
  - *enhance technology transfer and deployment*
  - *enable financial mechanisms*
  - *implement early warning systems*
  - *undertake risk management*
  - *address gaps in implementation and upscaling*

- Near-term action to address adaptation and mitigation, desertification, land degradation and food security can bring **social, ecological, economic and development co-benefits**.

- Co-benefits can contribute to **poverty eradication** and more **resilient livelihoods** for those who are **vulnerable**.



Rapid reductions in anthropogenic GHG emissions across all sectors following ambitious mitigation pathways reduce negative impacts of climate change on land ecosystems and food systems.

Delaying climate mitigation and adaptation responses across sectors would lead to increasingly negative impacts on land and reduce the prospect of sustainable development.

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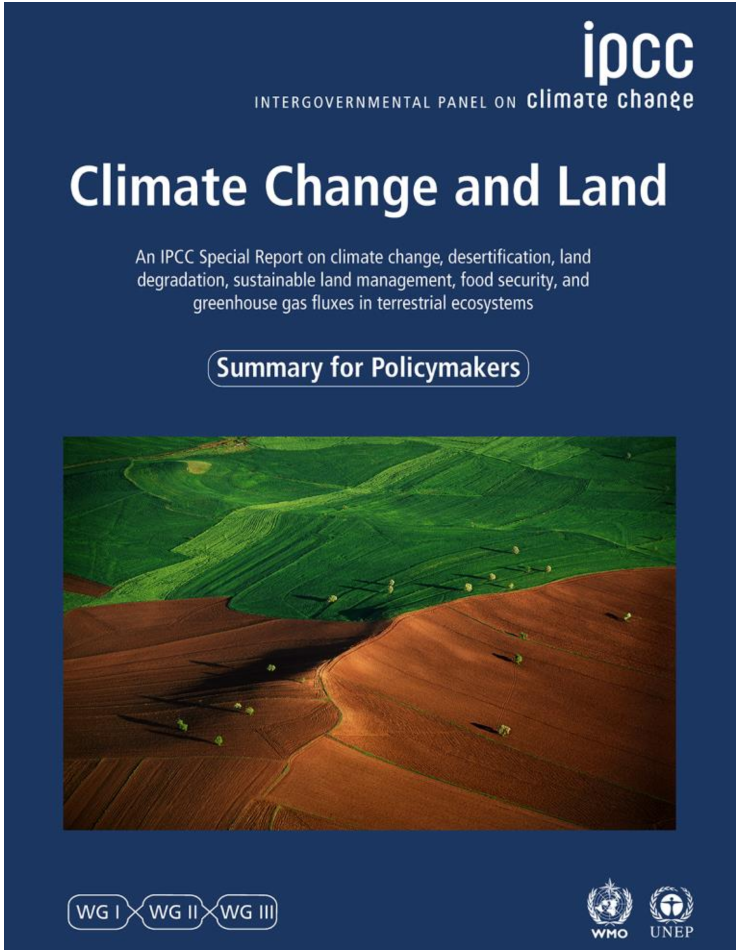
“ Land could feed the world in a changing climate and provide biomass for renewable energy, **but it can’t do it all**. It would require early, **far-reaching action across several fronts**.



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