

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)
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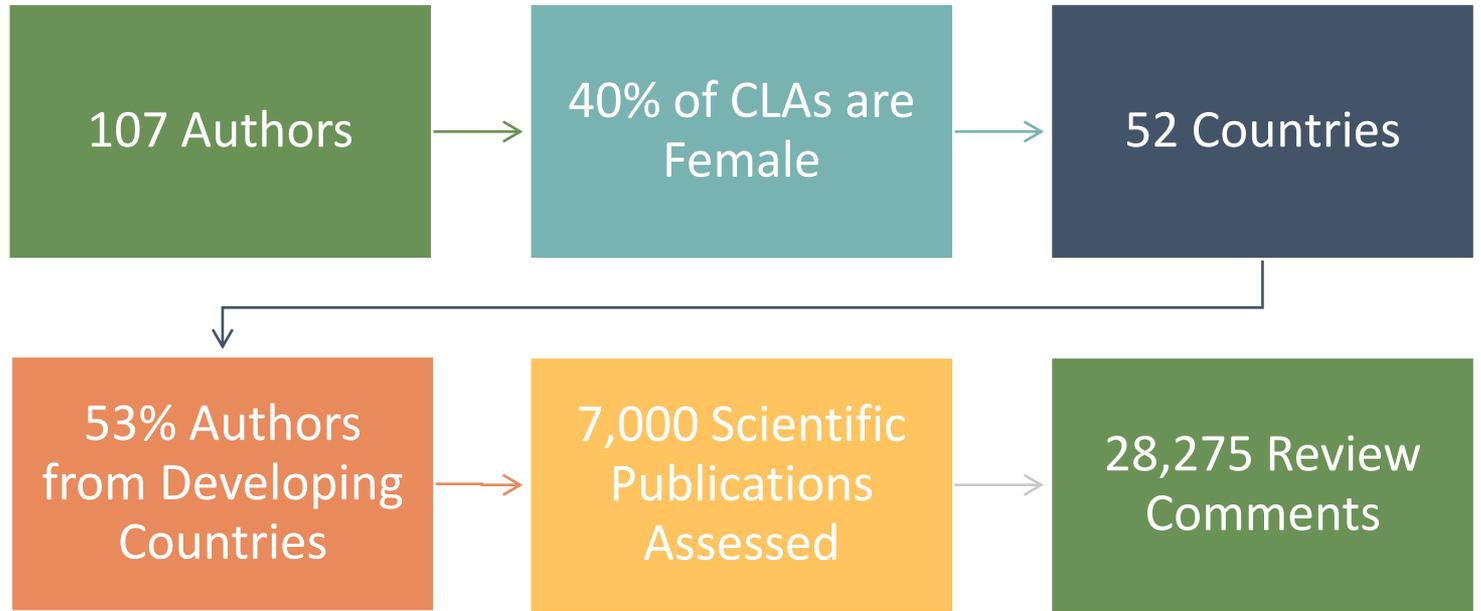
Dr Eamon Haughey, Trinity College Dublin and IPCC WGIII TSU

Evidence to Joint Committee on Climate Action

Wednesday, 16th, October 2019

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INTERGOVERNMENTAL PANEL ON climate change



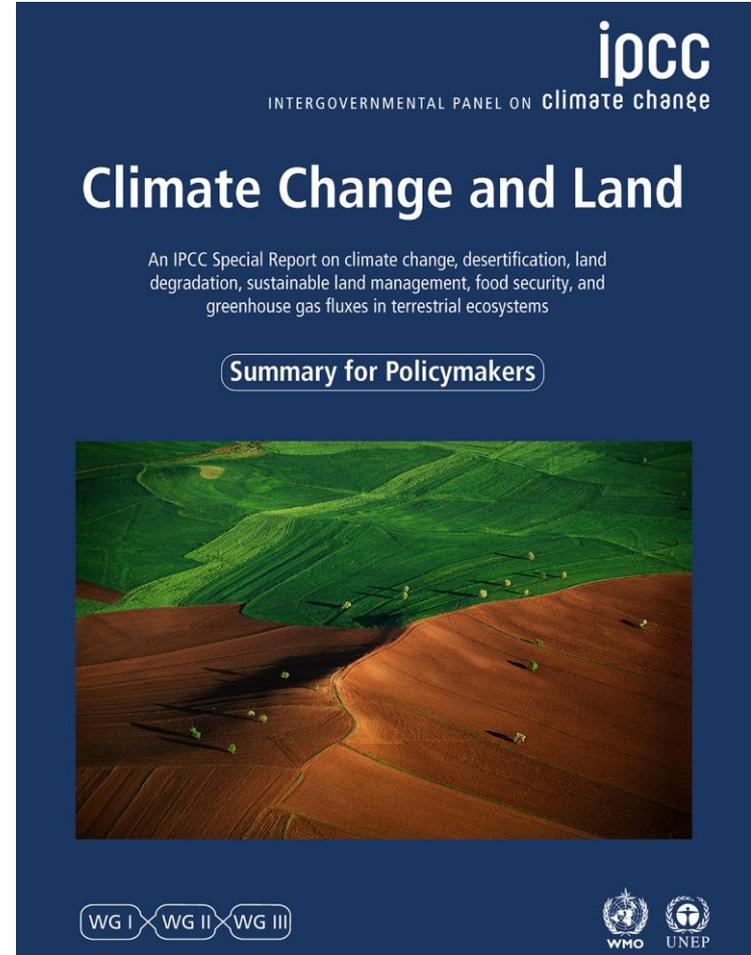


CLIMATE CHANGE AND LAND

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 where we live

Land is under
growing human
pressure

Land is a part
of the solution

But land can't
do it all

“ 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



Climate change is making a **challenging situation worse and undermining food security.**



Agriculture, food production, and deforestation are major drivers of climate change.

“ Coordinated action to tackle climate change can **simultaneously improve land, food security and nutrition, and help to end hunger.**



The way we produce our food matters; dietary choices can help reduce emissions and pressure on land.

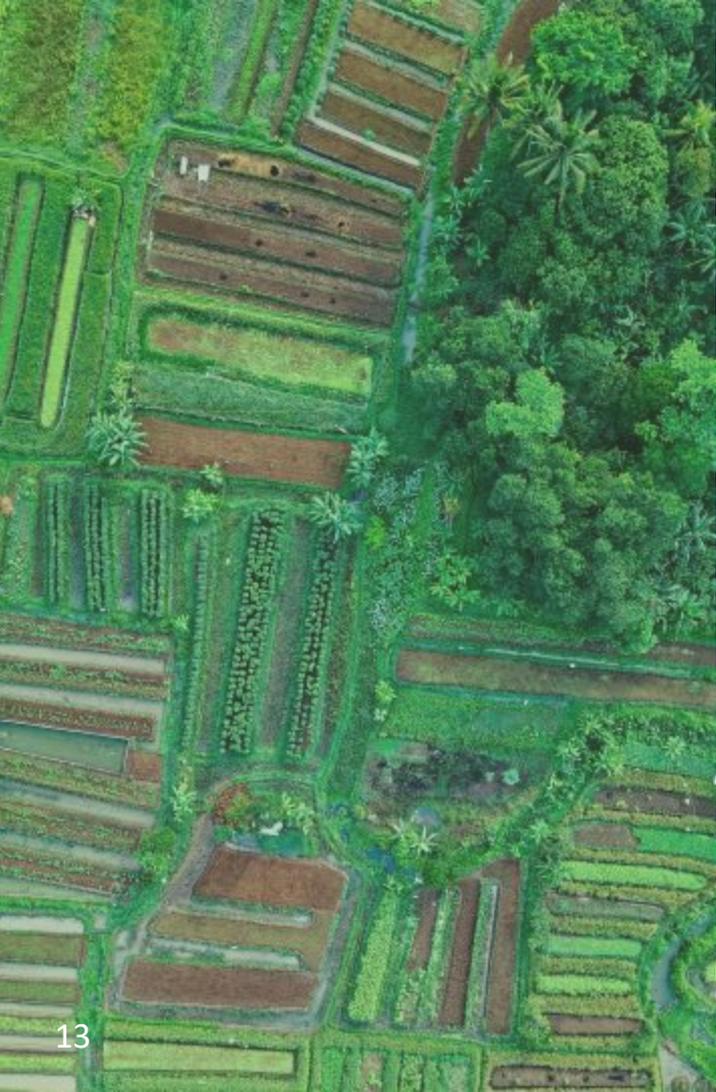


There are things we can do to both **tackle land degradation** and prevent or adapt to further climate change.

“ “ The land that we are already using could feed the world in a changing climate and provide biomass for renewable energy, but it would require early, far-reaching action across several fronts.



Better land
management also
supports
**biodiversity
conservation**



There are **actions available** to us that can simultaneously **improve land, enhance food security and improve nutrition.**

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

Land is where we live

Land is under
growing human
pressure

Land is a part
of the solution

But land can't
do it all

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

Summary for Policymakers



WG I WG II WG III

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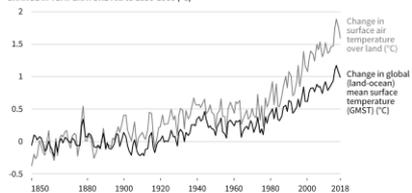
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Land use and observed climate change

A. Observed temperature change relative to 1850-1900

Since the pre-industrial period (1850-1900) the observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature (GMST).

CHANGE in TEMPERATURE rel. to 1850-1900 (°C)

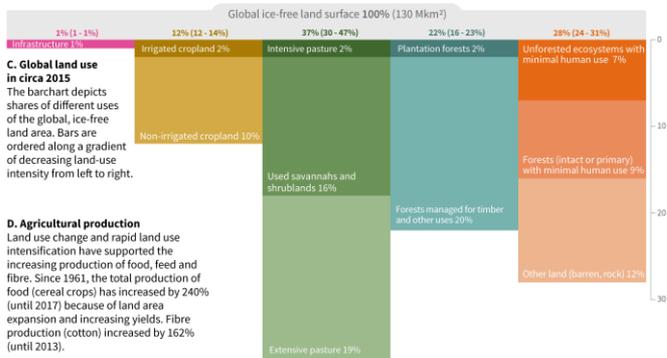
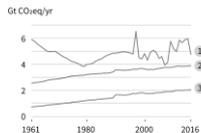


B. GHG emissions

An estimated 23% of total anthropogenic greenhouse gas emissions (2007-2016) derive from Agriculture, Forestry and Other Land Use (AFOLU).

CHANGE in emissions rel. to 1961

- ① Net CO₂ emissions from FOLU (Gt CO₂/yr)
- ② CH₄ emissions from Agriculture (Gt CO₂eq/yr)
- ③ N₂O emissions from Agriculture (Gt CO₂eq/yr)



C. Global land use in circa 2015

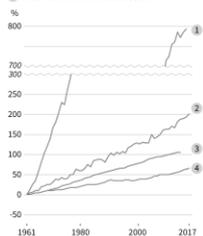
The bar chart depicts shares of different uses of the global, ice-free land area. Bars are ordered along a gradient of decreasing land-use intensity from left to right.

D. Agricultural production

Land use change and rapid land use intensification have supported the increasing production of food, feed and fibre. Since 1961, the total production of food (cereal crops) has increased by 240% (until 2017) because of land area expansion and increasing yields. Fibre production (cotton) increased by 162% (until 2013).

CHANGE in % rel. to 1961

- ① Inorganic N fertiliser use
- ② Cereal yields
- ③ Irrigation water volume
- ④ Total number of ruminant livestock

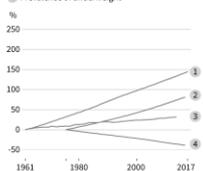


E. Food demand

Increases in production are linked to consumption changes.

CHANGE in % rel. to 1961 and 1975

- ① Population
- ② Prevalence of overweight + obese
- ③ Total calories per capita
- ④ Prevalence of underweight

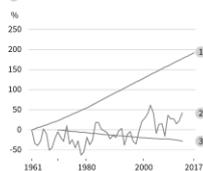


F. Desertification and land degradation

Land-use change, land-use intensification and climate change have contributed to desertification and land degradation.

CHANGE in % rel. to 1961 and 1970

- ① Population in areas experiencing desertification
- ② Dryland areas in drought annually
- ③ Inland wetland extent

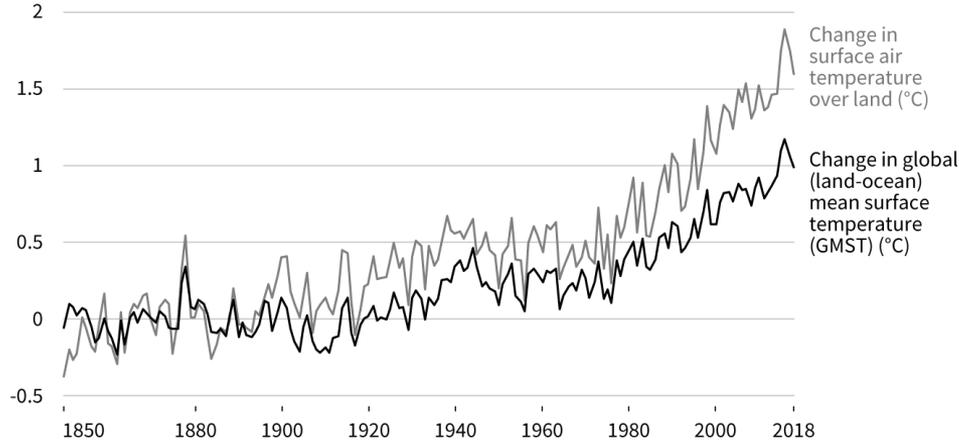


• Figure SPM.1

A. Observed temperature change relative to 1850-1900

Since the pre-industrial period (1850-1900) the observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature (GMST).

CHANGE in TEMPERATURE rel. to 1850-1900 (°C)



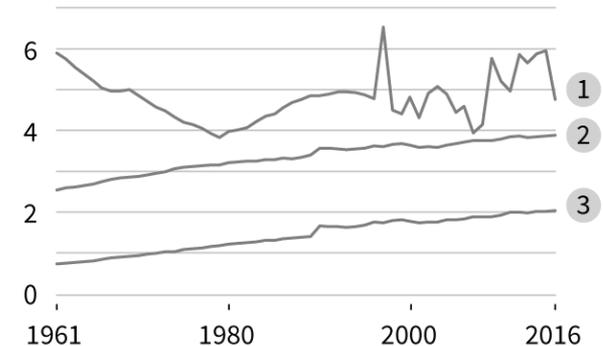
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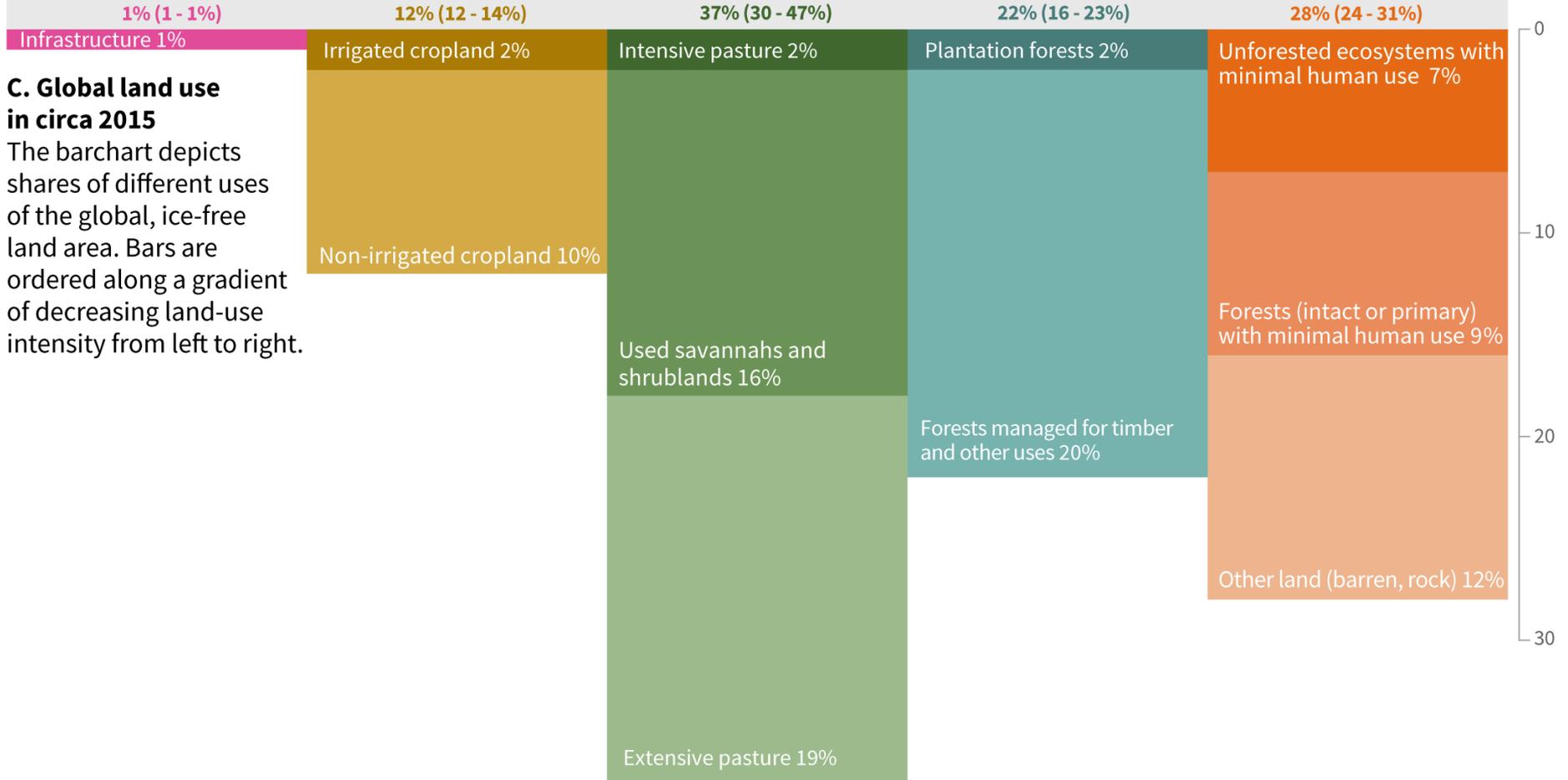
CHANGE in emissions rel. to 1961

- 1 Net CO₂ emissions from FOLU (Gt CO₂/yr)
- 2 CH₄ emissions from Agriculture (Gt CO₂eq/yr)
- 3 N₂O emissions from Agriculture (Gt CO₂eq/yr)

Gt CO₂eq/yr



Global ice-free land surface 100% (130 Mkm²)



C. Global land use in circa 2015

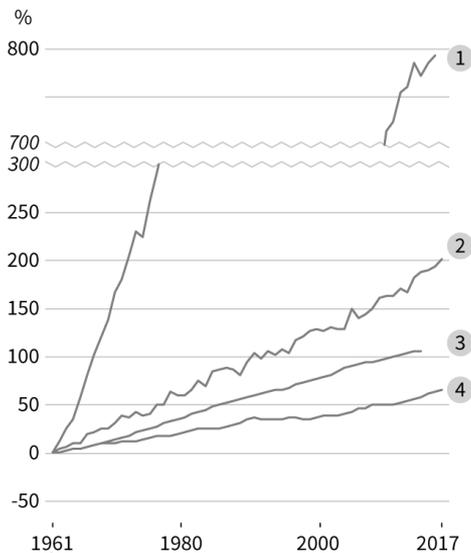
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Land use change and rapid land use intensification have supported the increasing production of food, feed and fibre. Since 1961, the total production of food (cereal crops) has increased by 240% (until 2017) because of land area expansion and increasing yields. Fibre production (cotton) increased by 162% (until 2013).

CHANGE in % rel. to 1961

- 1 Inorganic N fertiliser use
- 2 Cereal yields
- 3 Irrigation water volume
- 4 Total number of ruminant livestock

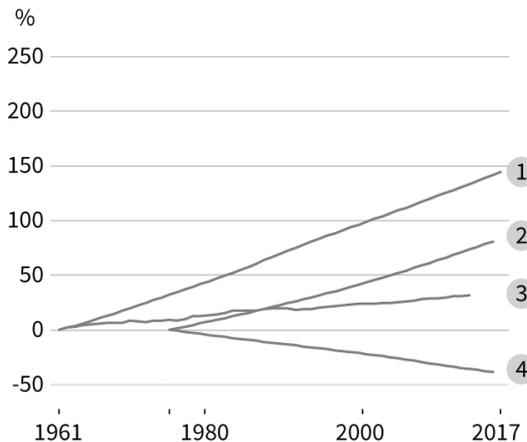


E. Food demand

Increases in production are linked to consumption changes.

CHANGE in % rel. to 1961 and 1975

- 1 Population
- 2 Prevalence of overweight + obese
- 3 Total calories per capita
- 4 Prevalence of underweight

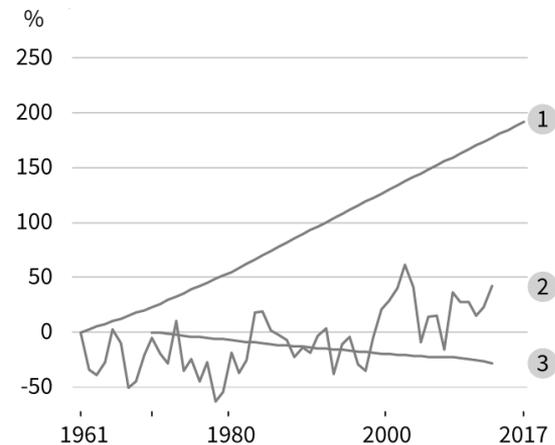


F. Desertification and land degradation

Land-use change, land-use intensification and climate change have contributed to desertification and land degradation.

CHANGE in % rel. to 1961 and 1970

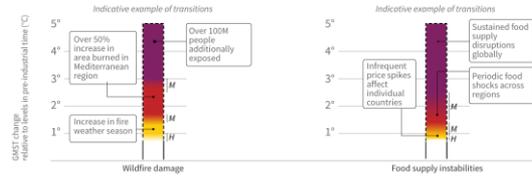
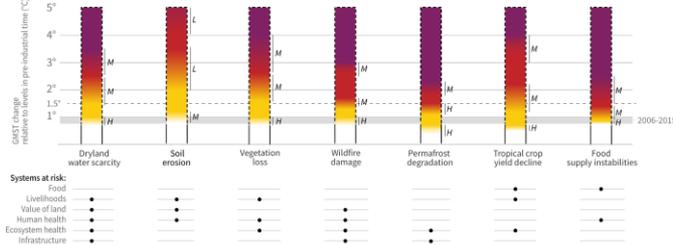
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- 2 Dryland areas in drought annually
- 3 Inland wetland extent



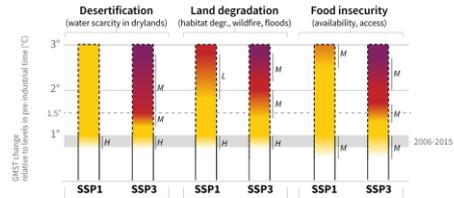
• Figure SPM.2

A. Risks to humans and ecosystems from changes in land-based processes as a result of climate change

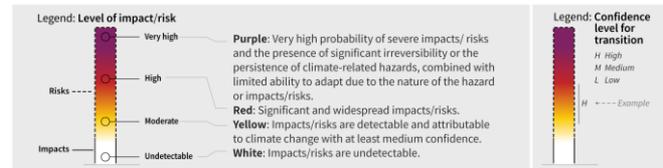
Increases in global mean surface temperature (GMST), relative to pre-industrial levels, affect processes involved in **desertification** (water scarcity), **land degradation** (soil erosion, vegetation loss, wildfire, permafrost thaw) and **food security** (crop yield and food supply instabilities). Changes in these processes drive risks to food systems, livelihoods, infrastructure, the value of land, and human and ecosystem health. Changes in one process (e.g. wildfire or water scarcity) may result in compound risks. Risks are location-specific and differ by region.



B. Different socioeconomic pathways affect levels of climate related risks

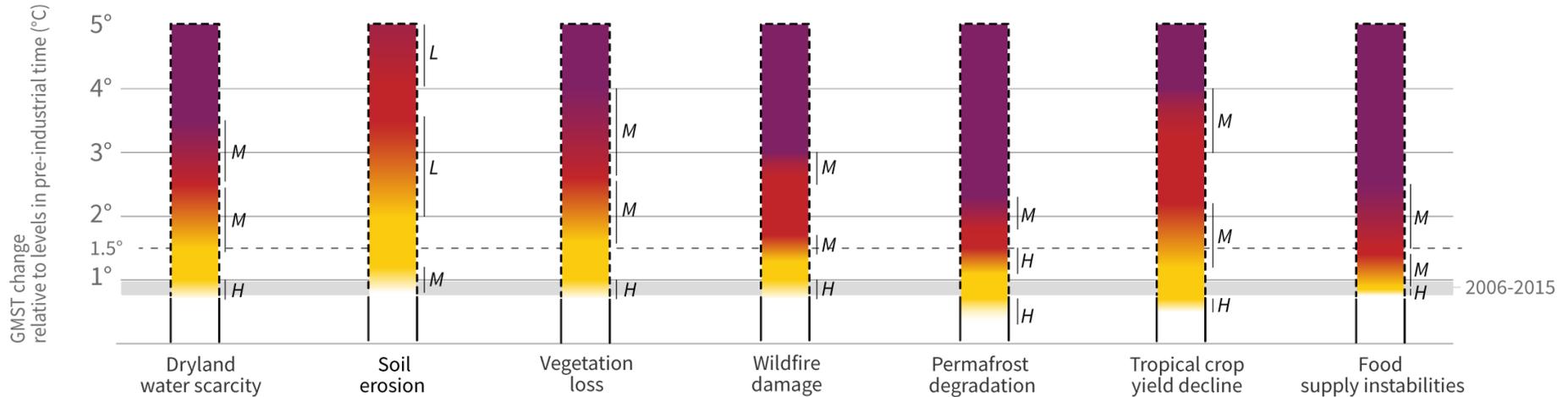


Socio-economic choices can reduce or exacerbate climate related risks as well as influence the rate of temperature increase. The SSP1 pathway illustrates a world with low population growth, high income and reduced inequalities, food produced in low GHG emission systems, effective land use regulation and high adaptive capacity. The SSP3 pathway has the opposite trends. Risks are lower in SSP1 compared with SSP3 given the same level of GMST increase.



A. Risks to humans and ecosystems from changes in land-based processes as a result of climate change

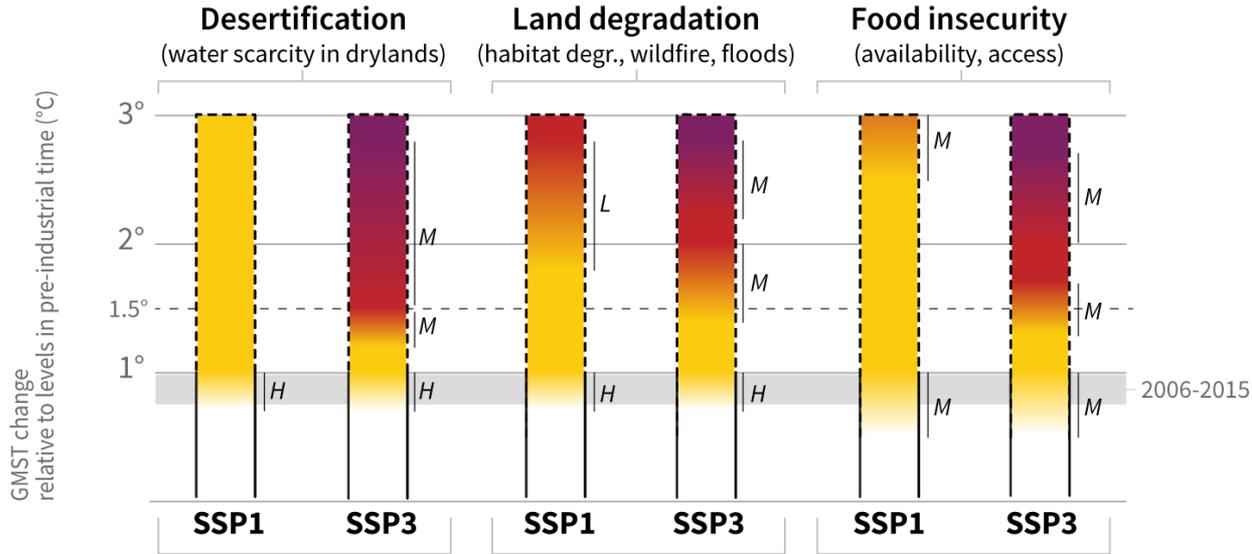
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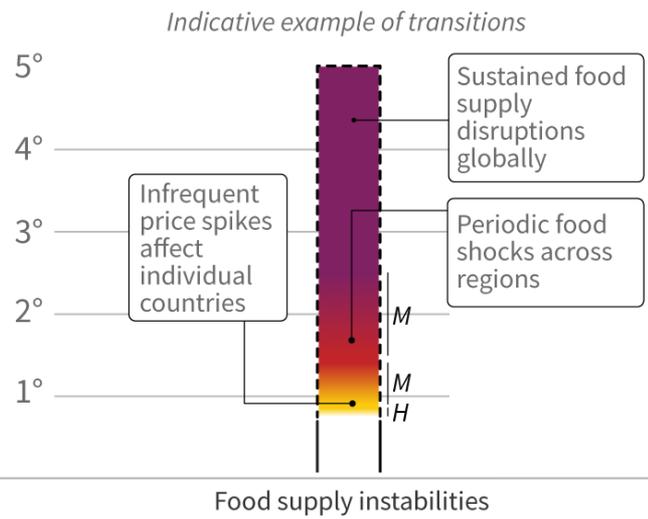
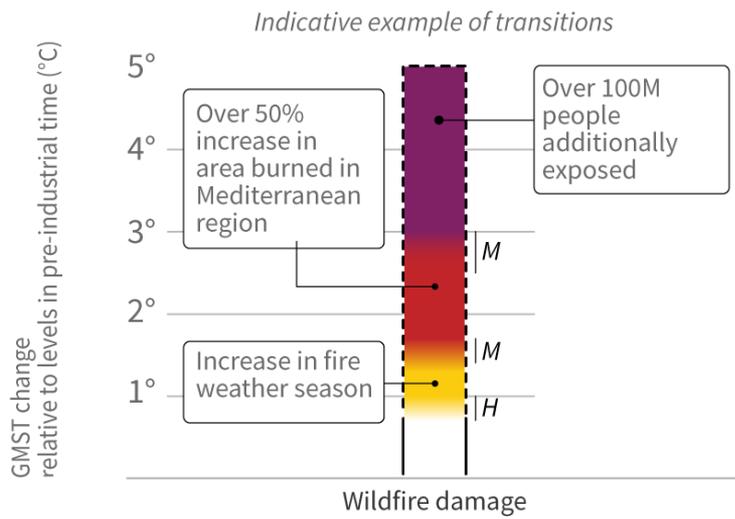
Systems at risk:



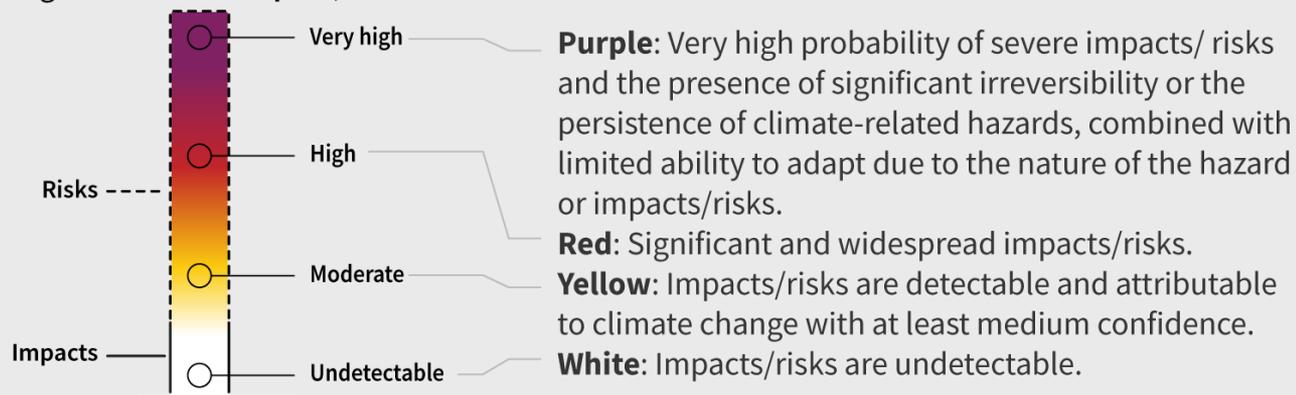
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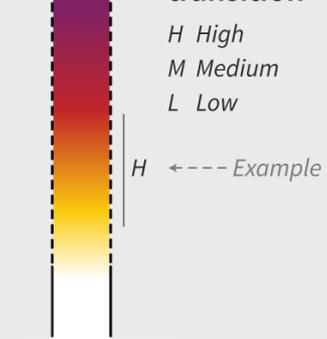
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Legend: Level of impact/risk



Legend: Confidence level for transition



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	●●●
Forests	Reduced grassland conversion to cropland	L	---	L	L	L	●
	Forest management	M	L	L	L	L	●●●
	Reduced deforestation and forest degradation	H	L	L	L	L	●●●
Soils	Increased soil organic carbon content	M	L	M	M	M	●●●
	Reduced soil erosion	---	L	L	M	M	L
	Reduced soil salinization	---	L	L	L	L	●●●
Other ecosystems	Reduced soil compaction	---	L	---	L	L	●
	Fire management	M	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	L	M	L	
Response options based on value chain management							
Demand	Reduced post-harvest losses	H	M	L	L	H	---
	Dietary change	H	---	L	M	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	---
	Risk sharing instruments	---	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 ₂ e ⁻¹ or US\$ ha ⁻¹ .	
●●●●	High cost
●●●	Medium cost
●●	Low cost
●	no data

• Figure SPM.3A

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	●●

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

	Mitigation <i>Gt CO₂-eq yr⁻¹</i>	Adaptation <i>Million people</i>	Desertification <i>Million km²</i>	Land Degradation <i>Million km²</i>	Food Security <i>Million people</i>
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
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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\$ tCO₂e⁻¹ or US\$ ha⁻¹.

 High cost

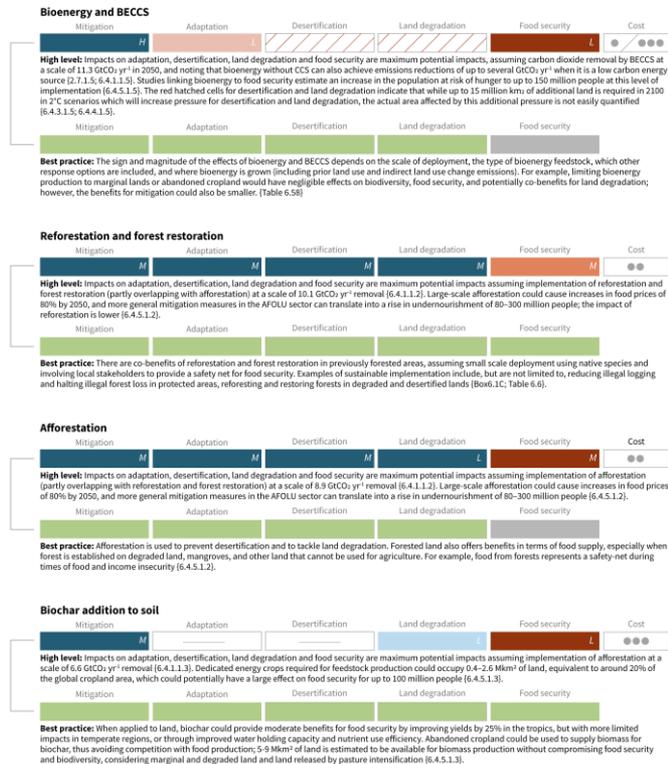
 Medium cost

 Low cost

 no data

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 CO₂ removals of more than 3 GtCO₂ 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.



• Figure SPM.3B

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 GtCO₂ yr⁻¹ in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several GtCO₂ 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 km² 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 GtCO₂ 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 GtCO₂ 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 GtCO₂ yr⁻¹ removal {6.4.1.1.3}. Dedicated energy crops required for feedstock production could occupy 0.4–2.6 Mkm² 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 Mkm² 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}.

• Figure SPM.4A

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.

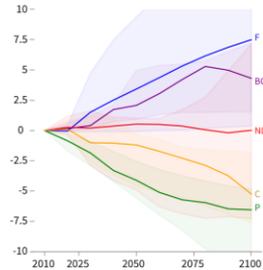
B. Middle of the road (SSP2)

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.

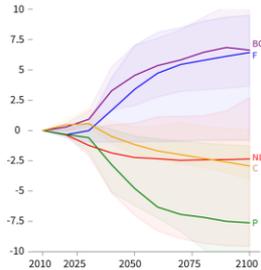
C. Resource intensive (SSP5)

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.

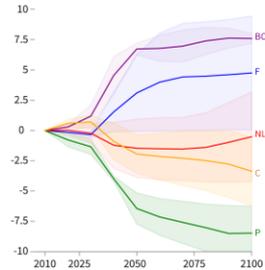
SSP1 Sustainability-focused
Change in Land from 2010 (Mkm²)



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



SSP5 Resource intensive
Change in Land from 2010 (Mkm²)

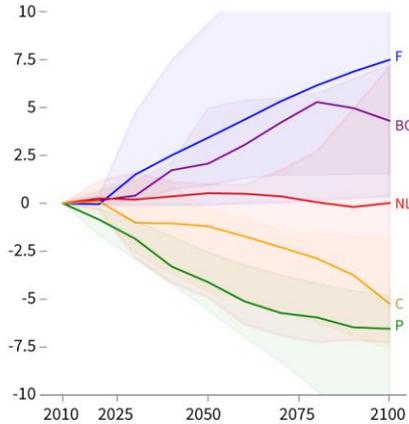


■ CROPLAND ■ PASTURE ■ BIOENERGY CROPLAND ■ FOREST ■ NATURAL LAND

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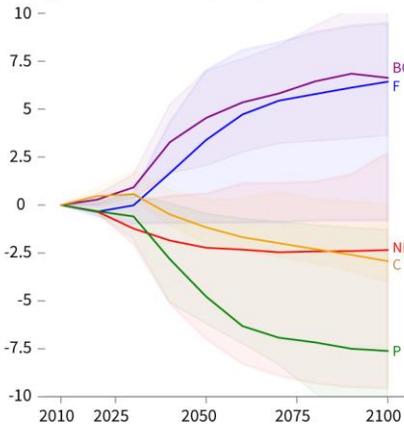
SSP1 Sustainability-focused
Change in Land from 2010 (Mkm²)



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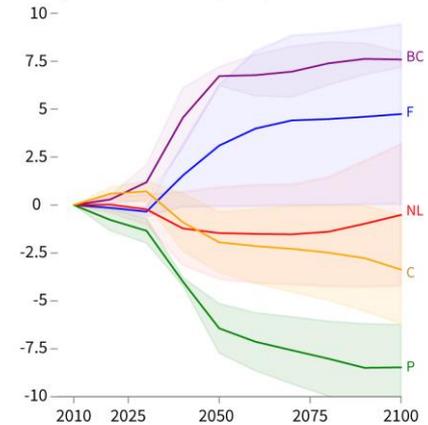
SSP2 Middle of the road
Change in Land from 2010 (Mkm²)



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.

SSP5 Resource intensive
Change in Land from 2010 (Mkm²)



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